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JOURNAL

OF THE

AMERICAN PEAT SOCIETY

A QUARTERLY JOURNAL DEVOTED TO THE DIFFUSION OF KNOWLEDGE OF THE UTILIZATION OF PEAT, AND THE DEVELOPMENT OF AMERICAN PEAT RESOURCES.

VOLUME X.

JANUARY 1917, TO OCTOBER, 1917.

TOLEDO, OHIO

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Journal of the American Peat Society

VOL. X JANUARY, 1917 No. 1

Tenth Annual Meeting of the American Peat Society, Washington, D. C., September 21-22, 1916

Prof. H. C. Thompson, of the Bureau of Plant Industry, opened the meeting at the Raleigh Hotel and acted as chairman of the convention.

The following officers were elected for the ensuing year:

President, L. B. Arnold, Duluth, Minn.

First Vice-President, B. F. Haanel, Ottawa, Can.

Second Vice-President, Prof. Peter Christiansen, St. Paul, Minn.

Secretary-Treasurer, Julius Bordollo, Kingsbridge, New York City.

The Executive Committee is composed of:

John N. Hoff, New York, Chairman.
Prof. H. C. Thompson, Washington, D. C.
John Wiedmer, St. Louis, Mo.
G. Herbert Condict, Plainfield, N. J.
A. J. Forward, Ottawa, Can.
Herbert Philipp, Perth Amboy, N. J.

Papers were presented as follows:

"Life in a Michigan Peat Marsh," by our retiring President, Carl G. Kleinstueck.

"Standardization of Humus Used for Fertilizer," by John N. Hoff.

"Peat a Source of Heat and Power," by Prof. Peter Christiansen.

"The Economical and Industrial Aspect of Peat-Moss, Its Uses, and Manufacture," by W. F. Todd.

"Bacterized Peat as a Fertilizer," by Robert Ranson.

"Field Operations in Relation to Peat," by John Olsen.

"Experiences in Ohio Muck Farming," by Ralph W. Jordan.
"The Management of Muck Land," by H. R. Smalley.
Illustrated Address, by Prof. H. C. Thompson.

In the afternoon of September 22 the members and visitors took an automobile trip to the agricultural experiment station at Arlington, Va., where the Bureau of Soils is conducting a series of tests with peat soils from various parts of the country. Each lady was presented with a bouquet of roses which had been grown on peat soil.

Our retiring President, Carl G. Kleinstueck, of Kalamazoo, Mich., was unable to be present at our Washington meeting on account of illness, he being in the hospital at that time. Shortly after our meeting, we regret to repeat, he passed away.

CORRESPONDENCE.

To the Editor:

I am in receipt of the October issue of the Journal this A. M. Condict's paper on dewatering peat is very faulty both in figures, theory, and practise.

They have had a press here for more than a year and I have offered them every facility to try it out at my place but it is gradually rusting and going to rot and will never be tried out.

For him to say that peat can thus be treated is to mislead those having the matter in mind.

ROBERT RANSON.

St. Augustine, Fla., Nov. 28, 1916.

To the Editor:

I regret that the "figures, theory and practise" of so eminent a peat authority as our friend Ranson have been so rudely bumped, but as he does not state in his communication just where the error exists, I do not see how reply can be made.

By all means let us have the truth, as I am as eager as any one to get at the facts.

As to the statement that the dewaterer has been idle for more than a year, while that is true, the unfortunate condition is due to circumstances which had nothing to do with the performance of the machine during experimental operation. Possibly Mr. Ranson has some apparatus in storage, which is there, not on account of some failure in operating, but on account of some other reason.

G. HERBERT CONDICT.

Plainfield, N. J., Dec. 12, 1916.

POSSIBLE PEAT DEVELOPMENT IN FRANCE.

On account of the high prices of industrial fuels there appears to be an increased interest in developing the peat bogs in certain regions of France. Peat has previously been worked to a small extent during the summer months, but the extraction has been made by hand, the fuel being used locally for domestic consumption. Peat litter or peat fertilizer has never been used in France.

PEAT INVESTIGATION IN SWEDEN.

A royal Swedish commission has been formed for promoting the peat industry, and this committee is thoroughly investigating what is being accomplished in other countries and the financial support given by their government and state bodies. H. von Feilitzen, Director of the Experiment Station of the Swedish Society for Promotinv the Culture of Peat Bogs, who is serving on this committee, will be remembered by many of our members as being present at the New York meeting of the American Peat Society in September, 1912.

Life in a Michigan Peat Marsh

By CARL G. KLEINSTUECK

(Read at Washington Meeting, Sept. 2, 1916.)

When, in 1880, transmigrating from Saxony to Chicago, I arrived in Kalamazoo, Mich., and concluded to stay over a few days to attend to some very "pressing" business with a young lady friend of mine, whom I had met in Europe, said good friend took me out for a ride in order to show me the sights of her native town.

Nothing much else along the line of sights being available, my friend conveyed me to the then already famous celery fields, to which Kalamazoo owes the euphonious surname of "Celeryville."

I do not enthuse over celery in the raw, consequently did not evince over much interest in the production, but my attention was at once and irresistably drawn to the peculiar character of the soil on which said celery was grown.

Jumping from the rig, I rubbed some of the intensely black, velvety earth (if earth it may be called) between my fingers, and astonished at the result, burst out: "I did not know that you had PEAT in America!"

In 1874 I had travelled over the eastern part of this continent, though only from city to city, and consequently knew nothing of country conditions, and therefore never had discovered an indication of the presence of any peat deposits; hence my great surprise six years later at detecting peat in Michigan.

My Good Friend replied: "But that is Muck; so, at least, we call it." "Well, call it what you please, the name won't alter its being fuel, and good fuel at that, and don't your many Hollanders around here use it for fuel?"

"No!"

A few days later I left Kalamazoo, pondering and wondering why such a valuable gift of nature, like the Michigan peat marshes, should not be utilized and, subsequently I settled down to "business" in Chicago.

Every time I returned to Kalamazoo my wonder at the apparent neglect of the industry of peat preparation, well known to every Hollander and Irishman, as well as many Germans, kept growing, but I was not undeceived until several years later

(1885) when I moved from Chicago to Kalamazoo to take up my residence at the outskirts of that city, and sleighload after sleighload of stove wood was offered at our door at 75 cents per cord.

That, of course, explained, and settled the peat question with me for the time being; but not for very long, as only the next spring (1886) found me busy digging and drying peat on a marsh corner of my farm in a large enough quantity to run the culinary department of the establishment by peat, and thus, as early as 1886 it was demonstrated to my thorough satisfaction that America not only held peat but peat burnable and good.

Other affairs engaging my attention and energies for a number of years, I did not find time to indulge in any more peat experiments, but never since my first day of arrival in Michigan (1880) have I lost interest in it, nor have I ever lost an opportunity to open the eyes of my fellowmen to the incalculable value of America's great peat deposits. The latter inclination became so much of a "hobby" with me that I was accused by a good friend of mine of having "peat on the brain."

This friend—president of one of the country's largest paper mills, which uses sixty to seventy million pounds of coal annually—occasionally runs so short of fuel that the vitality of his business is seriously threatened. He has already as much as admitted that he would thank his Creator on his knees for a sufficiency of the stuff that he said I had "on my brain" to overcome the alarmingly regular recurrence of coal pinches in his mill.

Some 25 or 26 years ago I was passing Gun Marsh, on a trip to beautiful Gun Lake. Noticing surface indications of peat deposits, I turned to the driver of the bus with the query, "Mr. Cornwall, how much is this kind of land worth per acre in this part of the country?" "Nothing!"

Why did I not buy the whole of Gun Marsh, some 25,000 or 30,000 acres of good peat land at that time?

As the years rolled by, I made occasional hunting, fishing, and boating trips down the Kalamazoo River, something like a hundred miles, to Lake Michigan; or up into the Northern Peninsula to Lake Superior, and to many of the beautiful lakes in closer proximity, and from each and every trip I returned with the knowledge of the presence of more and more peat deposits.

It has been claimed that the big coal strike in 1902 was needed to awaken interest in the peat industry of this country; which is true, but it is equally true, on the other side, that already in the early spring of the same year, and consequently before the mentioned strike, I was in the peat districts of Europe studying the work and ways of peat experts and peat establishments.

Armed with powerful letters of introduction from our Secretary of State, and from our Senator, J. C. Burrows, to diplomatic and consular officers abroad, sailed forth in February, 1902, to study European modi operandi in the peat fields, and many novel experiences were mine.

Right at the first place of landing (Rotterdam), I was informed "officially" that one concern in the southern part of Holland shipped to New York alone in 1901 18,000 tons of moss peat litter, which there (in New York) was sold as "Irish Moss" at the rate of $14 per ton.

I am almost, if not quite, certain that the same kind of moss peat can be dug and dried in New York or New Jersey for $2 to $3 a ton, and here in Michigan I have seen it in deposits warranting an average yield of 1,000 tons of dry litter per acre.

While in Holland I visited—incognito sometimes—the extensive peat works in Hellenaveen and Grundsveen, having to resort to more than one subterfuge to gain admission and information at these jealousy-guarded establishments.

From Holland I traversed my own native country from end to end in order to gain much needed knowledge in connection with the peat problem; paid my respects to Germany's and Austria's "big guns" in the peat world, joined the two peat societies there, visited Pomeranian and Oldenburg peat-coke works, and returned to Michigan by way of England, Ireland, and Canada, picking up crumbs of peat wisdom by the roadside as I went along.

Since then I have found peat beds as far north as Montreal and way south below Mexico City, high above the timber line in the Rockies, and in quantities immeasurable in all the States of the Great Lake region.

"Seek and you will find," and the man that seeks peat in America will find peat in whichever direction he may turn. There is one immense stretch of swamp land, inexhaustably rich in deposits of excellent fuel peat, traversing our State (Michigan) northeast from near South Haven on Lake Michigan to Saginaw on Lake Huron, not to forget the immense accumulations of peat in the cedar swamps of the Northern Peninsula and in every other part of the State. Nearly every one of our practically countless inland lakes is skirted with a more or less valuable belt of fuel peat.

Illinois has its Kankakee marsh; Wisconsin, as much as I have been able to discover from the trains, has enough peat "on hand" to supply the whole of the country with good fuel for a small eternity, and Iowa bids fair to furnish more.

Wherever I have seen rivers and lakes on this continent, I have seen more or less "turf" indications, plain and unmistakable

The Everglades in Florida consist of a more or less thick deposit of myriophillum, sphagnum, and carex, (Sawgrass?) peat in their entire width and length, something like 30 by 60 miles, and a cold day it will be indeed when our country's peat beds are exhausted for it will be centuries, if not millennia after the last "knobbin" of coal has gone up in smoke to soil the linen and infect the lungs of our descendants, none of which abominations ever is perpetrated by peat.

Convinced by ever increasing prices of oil, wood, and coal fuel, and more so by the constant fire and lumbering ravages of our timberlands without the least apparent attempt at replanting, that the country subsequently simply would be compelled, nolens volens, to use peat as the only available substitute, I commenced to absent myself from mankind in general and could be found poking around in the vast stretches of lowland in my vicinity, often for days wading hip deep through sloughs and inundated swamp lands, equipped with gun, ax, field glasses, compass and spade—a load weighing in the neighborhood of a half a ton and heavy enough for good roads, without having to flounder around with it all day in the bogs.

And I tramped and bored and trapped, tested and sampled until I was certain that I had located the best deposits of the State. This was in the fall and winter of 1901 and early spring of 1902, and consequently before the big strike had "put any fleas" into the ears of swamp-owning farmers. Then I concluded that the time for buying was propitious.

I succeeded in purchasing a few hundred acres of bogland in Gun Marsh, Allegan County, Michigan, and a similar number near Paw Paw, Van Buren County, all procured at ante peat-boom prices, though an overzealous newspaper friend of mine came pretty near spoiling my chances for advantageous buying by devoting a scintillating write-up to the fabulous possibilities of the peat industry. This was copied far and near, the wonders growing with each reproduction, and as a result every swamp-owning farmer felt himself an embryo millionaire and "hung on" to his marsh with an ever-tightening grip.

As the Gun Marsh tract was comparatively free of heavy timber, and therefore permitted easy operation with peat machinery, and especially on account of the cordial welcome and assurance of heartiest cooperation on the part of the town board and the citizens, I decided to erect my first peat plant at Gun Marsh, township of Martin, five miles east of the G. R. & I. railroad station at Shelbyville.

A few general remarks anent Gun Marsh, a 30,000-acre expanse of the richest lowland, may not here come amiss.

Up to 30 or 40 years ago Gun Marsh, extending in a south direction from the south end of Gun Lake (100 miles in cir-

cumference and renowned for its monster muscalounges) was densely covered with heavy timber: Ash, butternut, elm, tamarack and sycamore; but man first and fire afterwards have demanded nearly every tree of any value, and except for large tracts of "open" along the banks of Gun River, covered with a dense growth of marsh grass 3 to 4 feet high, an almost impenetrable jungle of swamp willows, briars and poplars has grown up. Only a few charred tree trunks of gigantic dimensions, lying prostrate on the ground, and innumerable root stocks burned down to the level—many of which grasps the ground for several rods in circumference—tell the tale of the former grandeur of Gun Marsh forests.

Surrounded by gently undulating hills and traversed in its entire length by Gun River, the only outlet of Gun Lake, even now the marsh offers in fair weather a rare picture of natural beauty. A few clumps of giant elms left standing and with the background of heavily timbered hills, it would furnish a worthy subject for the landscape painter's brush.

Gun River, intended by Mother Nature to serve as an outlet to Gun Lake, and a drain to Gun Marsh, has, by ruthless man, been perverted into an agent of inundation rather than one of drainage. Since the advent of the woodchopper and his portable sawmill along its banks, the river has been used as a general dumping receptacle and literally has been "choked up" by the accumulations of years of saw dust, tree tops, stray logs and all sorts of lumber-camp refuse, until at places it has become almost impassable for even the lightest of canoes, and, instead of carrying off the water from the lake and marsh after occasional rains, it brings the water rolling all over the moor. And it does rain there off and on! The water sometimes rises 6 inches within a single night.

In view of this condition, some of my neighbors and I have bent every effort and spent every cent we had to spare in the direction of procuring legal permission and, later perhaps, governmental aid for a thorough straightening and dredging of the now extremely tortuous and clogged-up Gun River—30 miles of waterway over a 10-mile air line!

The projected drainage of Gun Marsh will throw open to cultivation 25,000 to 30,000 acres of the most productive soil on this continent, which now are lying idle.

All our opponents are interested more or less heavily in the beautiful summer resorts that skirt the shores of nearby Gun Lake and fear a lowering of the lake's level from the proposed drainage. Their fears would be grounded and their opposition justifiable if the projected river work would have any earthly chance of affecting in any way whatever the lake's level.

However, as the dredging proposed is not to commence except several miles beyond the lake proper, and as it is generally conceded that water has the peculiarity of running down hill, it is an utter impossibility for the dredging to affect in any way the water supply of the lake, and to many it seems little short of wicked that the gross ignorance of a handful of pleasure seekers should stand in the way of the bread and butter of hundreds of needy. For the 30,000 acres of exceedingly rich marsh land—once effectually drained—would not only furnish employment for hundreds, but would produce enough of a harvest to feed thousands!

Some land around the marsh's edge,—though not as rich as that in the center, but because of being somewhat higher and, as a consequence, better drained, produces, year after year, a crop of 400 to 700 or even 800 bushels of onions per acre, and other marsh crops in proportion.

Thanks to unrelaxing energy on the part of all interested, our project of river draining had passed through all the preliminary stages up to the opening of the "bids" on the work by the county drain commissioners, when two injunctions were levied on all further proceedings and—there we stand to-day.

Nor was river dredging the only item of importance in our prospective marsh development; it is stated Gun Marsh is at certain times (a nearby neighbor says 13 months per year!) inaccessible by dry land, and month after month in 1902 my men and I had to wade in and out of the bog to my land, a mile from the edge, and back at night, often drenched to the bones, from working hip deep in the ditches and getting soaked by rain from overhead, having to sleep in an equally soaked tent on terra firma near the marsh's rim.

Consequently, I bent my next efforts to obtaining a road firm enough for preliminary purposes, and thanks to the highly appreciated generosity on the part of our board of supervisors and a trump of a highway commissioner, a road was built in 1903 about a mile long, from the marsh edge up to my land, and in the year following it was extended to my peat plant, another half mile. From that time on I have been able to reach my "establishment" with double team and heavy (½-ton) loads.

Previously, and especially during the long extended period of moving into the marsh, which we commenced in real earnest in the winter of 1902, the absence of a safe road proved a most serious obstacle in the progress of developments, and many a load of timber and machinery had to be piled up at the side of the marsh in winter until the receding waters would expose enough land in spring to allow the mud-shoe-guarded horses of the neighborhood a safe passage into the bog.

And ever since then it has remained a mystery to me that all the ponderous machinery, tons and tons of iron rails and heavy beams of timber could have been moved in, a heavy 20 h. p. vertical boiler could have been erected on the wobbly marsh, and shed after shed could have been raised, all without any serious loss or accident of any kind.

True enough, on more than one occasion the poor horses were floundering helplessly in the seemingly bottomless mud, or got "snagged" by upturning planks or branches, but, taking all in all, the moving was a marvel of successive good luck.

Only the loss of precious time, in the face of the more and more urgent call for peat from every side, was sometimes more than galling. Few have even a remote idea how much time occasionally will be required to execute, on soft, yielding marsh soil, a certain piece of work which on high and dry land could be accomplished in a comparatively short time. For instance, it took me and two much more able-bodied assistants, and a team of strong marsh-broken horses, full half a day to do nothing but turn around a broad-tire truck wagon loaded with a light gasoline engine and steam pump. It was facing east by noon when we began and west on the same spot when darkness interfered with further operations. On solid ground one man with team could have done the same job in five minutes with ease. It took several cars to convey the complete peat plant I had purchased in Germany from New York to Shelbyville on the nearest railroad.

This plant had to be placed in position; drying sheds, stable, engine house, camp buildings and tracks (¾ mile) had to be built; dummy cars had to be constructed, etc., before we could produce a single "sod" of peat, and the demand for fuel peat was getting more and more urgent week after week.

I engaged carpenters, machinists, men in general, and went to work with them with a will and an object.

Although a few weeks of experimental work had been done by hand late in the fall of 1902, we did not begin machine digging and pressing of peat in real earnest until about August, 1903, by which time we had, in a way, everything needed in position for action. We had a 20 h.p. engine and boiler, ready to run, a Dolberg peat press of 80,000 bricks daily capacity, and two Dolberg digging machines sufficient to excavate enough of the crude peat in one week to run the press for three days. We had our portable tracks constructed and tarred and our dummy cars and sheds, in fact everything necessary, in place and shape, ready to begin—everything except the men to run them.

Needing a complement of about 25 good men to run one plant to its full capacity, I had in good season "turned to" and

done my best to procure the necessary quota of "hands" but was in this one respect doomed to bitter disappointment; eight men were all we were able to muster at the outset, nine was the highest I ever obtained, and frequently I have been reduced to a couple of men or even none at all.

Determined to turn out some peat fuel at all hazard, I worked with the eight men on the digging machines until enough of the raw peat was piled up on cars and along the track to run the press for a couple of days. Then I "heated her up" at about three in the morning, had a good head of steam on, when the men appeared on the scene at seven, and then the nine of us would turn to and send engine, press and cars aflying. When the triple-deck conveying cars had been loaded, each with 210 freshly made "sods" we would shut down steam, stop engine and press, and all nine of us would help unload the conveyors. Then we all would go back to pressing as long as the raw peat lasted; after this we again manned the diggers.

Thus, we managed to produce, under difficulties, a few hundred thousand peat bricks and the sight of our gradually but surely filling drying grounds made my heart feel glad indeed; for the sight of this, I had longed and battled hard for many years.

At that time, about the 20th of August, 1903, the peat was dry enough to be hauled in from the drying grounds to the sheds, and I began to send for teams and teamsters to assist in the harvest of our first crop.

Then came a very threatening cloudy Saturday with only two men reporting for work and then a Sunday on which I felt anything but pious, for towards noon it began to sprinkle, then it rained, slightly first, but gradually more and more heavily; then it poured and poured until it appeared as if all the floodgates of heaven had been let loose on us and our work. It rained days—it rained weeks; it rained fortnights and months. Literally all of September, 1903, and two-thirds of October consisted of almost uninterrupted rainfall.

After five or six days of almost incessant rainfall, accompanied by a puffy east wind, the ground, as far as eye could reach, slowly but irresistably disappeared under the ever rising waters; the clouds hovered lower and lower; there was not a dry stitch of clothing on my anatomy, nor, for that matter, anywheres within a radius of miles; our tents were sappy and soggy; our "grub" was running low, and our next base of supply was a "sea" mile or two off on a submarine road; my helpmates were driven away by the flood—verily under those conditions a Michigan peat marsh does not compare over favorably with the Trocadero, Palm Beach, Petoskey, Chepultepec or

Swinemünde, and the solitary human inhabitant at those times feels a strong inclination to range the monks of Fécamps (who brew that nectar called "Benedictine") and those of the Chartreuse, alongside of the greatest benefactors of the human race.

And yet, for the eye that sees and for the hearing ear and the mind that is open, there is beauty and recreation and no end of highly interesting and instructive revelation even in the "dismal" swamps of Michigan.

Fate had decreed that my lot should for a while be cast with the inhabitants of the lowest lowlands and, strange as it may appear, right pleasant and agreeable companions I have found by far the most of them to be.

Our first camp in the very heart of Gun Marsh was hardly staked out and temporarily roofed over in the early spring of 1903, when a remarkably tame cat bird, his mate was nesting in a bush near by, chose to pay us almost constant visits whenever we were in camp, fearlessly alighting within a very few feet of us, on the back of our chairs, on top of the half open door, even on our improvised camp table, never taking anything, but just peaking-peaking; and oh! its glorious song in the evening!

A little song sparrow—always chirp-chirping, literally kept me company all season, picking up crumbs within two or three feet, provided I was alone. Company always kept her off a rod or two.

When we are alone with mother nature she always is strangely communicative if we will but look and listen, especially towards evening. Seemingly, the marsh is perfectly quiet, no sound disturbs the vast expanse. The moon plays hide and seek among the clouds and all seems peace eternal. The fire-flies in countless myriads luminate the moor, and every leaf and blade is glistening as if tipped with silver.

Mink, weasel, rabbit, the exceedingly rare kangaroo, mouse, muskrats, several species of groundmoles, mourning doves, ducks, wild geese, herons, woodcocks, snipe, killdeer, prairie chickens, partridges, quail, coots, loons, owls, different kinds of hawks, Caroline rail, songbirds in endless variety, 13 different species of turtles and other reptiles,—all can be seen at one time or another right from our camp, and in the night one can hear the "hollering" of the racoon, the boom of the great bittern and the hoarse barking of the fox; 45 rattlesnakes killed in one season (1903) is certainly a good showing for this useful and noble sport.

And right here permit me to dis-illusionize the enthusiast in regard to the alleged "friendly" warning rattle of his snakeship; he never rattles if anything unexpected appears on the

scene; unless he is thoroughly rattled himself! Several years of closest devotion to the study of his habits have irrefutably convinced me of this fact. My last victim—dispatched only a few weeks ago,—never sounded the ominous, nerve-racking signal until my ever ready hand axe had completely severed his head from his body. He was stretched full length along a fallen tree and I discovered him between my knees just as I was standing straddling over him.

Numbers of them did not emit their danger signal until my foot was either directly over them or until I had completely walked across them. And in every instance the "varmints" in question could not help seeing me long before I was upon them for it is unwise to move otherwise than slowly on the marshes. When moving around in the bogs, for the sake of safety I always carry with me a vial of the strongest aqua ammonia, the only reliable snake poison antidote known.

Besides the massasauga (swamp rattler), the dear little mosquito, the checkered-legged "gallinipper," and the national "bird" of the strong odor (called sometimes "wood-pussy" or Mephitis Mephiticus), perhaps might be classed with the unpleasant or even offensive of our neighbors in the swamp. All the rest is in completest harmony with us! There was a nest full of young marsh hawks discovered accidentally within a few rods of the sheds on the ground in a clump of young willows. Raised under my personal supervision, although reported very shy birds, the youngsters of that batch, show to the present day their appreciation for my care and forbearance by sailing, calling and hovering remarkably near and around me when I am alone in the "open." What dash, what grace and power in the marsh hawk's flight. Each wing stroke draws a curve of perfect beauty! Storm-cleaving, screaming, sailing in the clouds, he is monarch undisputed of the lowlands.

By the way! I never saw my young marsh hawks receive any other food but snakes, frogs, mice, and one gopher. Who, but a fool, would kill such useful birds? And a rare treat for eye and ear it was indeed to observe papa marsh hawk, screaming from high among the clouds, across miles of marsh, calling mama marsh hawk, who presently could be seen to swiftly and noiselessly steal from the nest, sail low a little way, close to the grass tops, then suddenly rise high into the air on mighty wings, to meet her mate in midair and relieve him of the trophy of his chase.

And then would follow a scene high up in the ether which none favored with its sight would easily forget. After one or two more shrill screams, the male would drop down to his

fast approaching mate, one more air-cleaving curve, a touch of both big birds in mid air, one defiant scream of the fast disappearing male, and the prey, usually a squirming snake, which but a moment ago was seen dangling from the sharp talons of the male, was hanging in the female's claws.

Just as noiselessly as she came, the fond mama returns to her ever hungry brood, while papa marsh hawk resumes the chase. There's method in the noise of the male and the quiet, stealthy coming and going of the female! Plenty of noise away from the nest—nary a sound near it! See?

As the season advanced and the young hawks grew larger, I have frequently seen the old bird come scooting across the moor, scream a signal or two, stop hundreds of feet straight above the nest, and drop a frog or snake as accurately and unerringly into it as if the prey had been shot from a sharpshooter's rifle.

Twice in 1903 I had the good fortune of seeing "Old Baldy," the venerable bald-headed eagle (whose mate was killed here over fifty years ago) and who yet pays occasional visits to the land of his first love.

Students of ornithology could not possibly find a richer field for observation than the marsh. Late in the fall, especially, countless millions of redwings, goldwings and buntings can be seen. Honking wild geese, often in flocks of over a hundred, phalanx their course of flight across the lowlands and some nights the almost incessant whistling of the wild ducks, cutting the air with wiry wings, may be heard in every direction.

Even the graceful little humming bird is occasionally in evidence. I have seen a pair of them put a huge blackbird to a most ignominious retreat. I have also repeatedly witnessed the swift celebration of their nuptials on the wing.

Robins congregate and nest in immense numbers all over the marsh and the night hawks and whip-poor-wills are in regular attendance every night. A pair of fly-catchers have raised several broods among the rafters of our "dormitory" and all during the winter of 1903-1904 a screech owl shared with us the shelters of our camp.

The greatest drawbacks to the life in the marshes indubitably are the countless cohorts of mosquitos—in their season—though one gets more or less inured to their bites after awhile, but never to their music. I have walked for miles through dense clouds of them, without getting "bit," but their chilling bugle calls would drown or distort every other sound and at times my own footfalls seemed to sound a quarter of a mile or so ahead of me. An ever-going peat smudge keeps our camp completely clear of the "pesky" mosquito.

PENNSYLVANIA STATE LIBRARY

There is much in Gun Marsh to remind one of Florida and its Evergreens. True, we have no saw grass here, nor egrets, alligators, terrapins, water moccasins, and the like, but we have water here, plenty of water! Our half-bushel-size snapping turtles are every whit as ferocious as the few remaining undersized "gaitors" of the "Glades" that have managed to escape the pot hunters. For the one species of turtles (terrapin) in the Everglades, Gun Marsh has over a dozen different kinds. Our massassaugas are warranted to kill just as dead as the nasty looking, hideous water moccasion of Florida. Our great blue heron on the wing is not one particle less majestic than the almost extinct egret. The Florida limkin, with his abominable all-night squawk, stands but a poor show alongside of our great bittern with his soothing basso profundo "boom-bang-boom," and our marsh hawk is not one feather less graceful and less forceful than the Florida Everglade kite. We do not have the pelican, but we have a pretty satisfactory substitute in the cheerful loon.

Our marsh grass is perhaps not quite so high as the saw grass in the "Glades," but then it does not cut our boots, pants, hands, and faces, and if our Michigan Pottowattomies do not dress quite as picturesquely as the Seminole chief, "Billy Tigertail" (on whose island I pitched my first camp in the "Glades"), our Pottowattomies are every bit as skillful canoeists, trappers, and hunters.

And even the temperature of Gun Marsh invites comparison with tropical Florida, for we have repeatedly seen the thermometer rise to one hundred and thirty and even higher in the sun, although the nights here on the marsh are almost invariably cool, or even cold. From near the freezing point at early dawn, we've often seen the temperature rise to a hundred and above (in the sun) within six hours, to drop again at dusk to 50 below.

All the large game that roved Gun Marsh forests in former times is gone, of course, never to return, but the occasional find of huge elk horns, bears' tibias and wolf skulls in the peat's top layers testify eloquently enough to the not very remote presence of those "monarchs of the woods."

To return to peat—(as is) stated, all our work done in the earlier part of 1903 was completely ruined by nearly three months of continuous rain. Our several hundred thousands of peat-bricks were "in the soup" literally and soon had melted into a mushy liquid.

We managed to do a little more pressing late in October (1903) but the season came too soon to a close to allow complete drying of all the bricks thus obtained. However, we succeeded in saving enough for samples and my own house-

hold needs for the approaching winter. My furnace was peat fed during the most of the winter of 1903 and 1904, and my kitchen range has been kept going uninterruptedly on peat ever since 1903.

Unfortunately the abnormally high water stand of 1903 permitted excavations only in the most elevated places of the marsh. The peat there is considerably inferior to the rest, yet all those that received samples spoke encouragingly about them.

By means of only such poor samples, I could have sold thousands of tons of peat in 1903. The winter had scarcely begun when my mail commenced to swell with inquiries for peat and its price.

Once in 1901 my better half said scornfully to me, "Oh, you may get your countrymen and the Dutch and the Irish to use the dirty stuff (meaning peat), but you will never get a 'real American' to like it!" To which I replied with appropriate dignity, "Your excellency, mark my word, within a comparatively few years it will not be a question of liking or disliking peat as a fuel, but simply a question of using peat or freezing."

It was not quite ten weeks later, when people froze to death in Chicago—almost within sight of inexhaustible peat deposits.

I forgot to inquire whether the poor victims of cold winter were "real" Americans or not, but I presume that everyone of them, regardless of nationality, approached at the proper time, would have cast every bit of native pride to the wind for a basket of peat.

My past experience, covering nearly half a century, justifies me in scenting "trouble ahead" for everything I tackle, and as a consequence I was prepared for obstacles galore in connection with introducing peat, but for once I have been mistaken in this regard, for I have had my hands more than full writing refusals to bona fide peat orders and, quite contrary to my better half's predictions, the "real" American has been by far the most numerous and interested of my correspondents.

Above all, my life partner, who is herself a "real" American, stands today, after several years of practical experience of peat heating in every firing apparatus in the house, the most enthusiastic advocate for peat fuel in the country!

Inability to get help made it next to impossible for me to press any peat in 1904, but I managed to dig and dry in the raw enough peat to keep us and ours warm and to do our cooking for another season.

Concluding, I beg to state that I have no stock company organized for the purpose of selling shares. My main object in the matter on hand has been the general introduction of peat for fuel. If I have, in part, so far failed to accomplish this, it has been simply because I could not possibly help it. Yet, other serious obstacles having been surmounted, the few remaining ones will in all probability be overcome in time.

So far I have to be satisfied with the contention that I have honestly done my best to set the stone arolling. May it roll on and on and never stop until there are no more coal famines and cold homes in this otherwise so abundantly rich and blessed country.

Standardization of Humus Used for Fertilizer

BY JOHN H. HOFF

(Read at Washington, D. C., Sept. 21, 1916.)

Humus is animal or vegetable matter in varying stages of decomposition—the decayed remains of previous generations of plants and animals. Obviously no substance derived from such a complex source as the whole organic life of the world can be absolutely uniform in constitution. Although the variability may not be great enough to permit us to say that every species of plant would give us a different kind of humus, nevertheless it is readily apparent that the original material from which humus is derived has an intimate bearing on the nature and value of the humus produced.

Broadly speaking, any organic matter will produce humus under proper conditions, but the humus formed from sawdust differs radically from that derived from red clover. In nitrogen the former is woefully deficient, whereas the humus formed from clover is not only rich in nitrogen, but also properly balanced by the presence of phosphorus, potash and lime.

Pure animal matter, in turn, would give a richer humus than clover, but as animal humus comprises such a small percentage of the soil organic matter, it has received a correspondingly small amount of study and attention. For extensive, practical agriculture the residues of leguminous plants afford the best quality of raw material for forming humus.

Let us grant then that the type of organic material is important. Consider next the influence of the environmental conditions under which our humus is to be formed. Both chemical and biological agencies are operative, the latter being undoubtedly the more important.

Soil organisms derive their energy almost entirely from the soil organic matter, and as only soluble substances can be ingested by the bacteria, we readily see the importance of humus solubility in determining the bacterial population of that soil. The converse is likewise true that the solubility of the organic matter has been effected by the bacterial enzymes, but

to what extent the enzymes can be efficient depends primarily upon the type of raw material present. Automatically we have been lead back to our first concept—that of the nature of the organic residue to be humified.

Of equal importance is the relation of solubility of humus material to its value as a nutrient for higher plants. The late Doctor Hilgard, emphasizing the importance of solubility in humus, states that the nitrogen in the active or soluble humus has fourteen times more availability as a plant food than the nitrogen in the undecayed portion of the soil's organic matter.

I do not believe that too much emphasis can be placed upon the solubility of humus as a means of judging of its agricultural value. Both the higher and the lower forms of life require that their nutrients be in soluble form and this would seem, a priori, to be the logical basis for comparison.

Most of our estimates of the value of humus are based on the straight chemical analysis. An analysis of a humus soil is an even less accurate index of its agricultural worth than it is for the mineral soil. Samples of a raw, sour, water-logged muck might on analysis have the same quantities of nitrogen, potash and phosphorus as a sweet, fertile humus soil. Their crop-producing powers would differ as widely as those of a salt marsh and a fertile loam and yet the chemical analysis might not give an inkling of this variation.

To illustrate: In a comparison of a New Jersey and an Indiana muck soil, cauliflower was grown in the green house. The New Jersey muck, without fertilization, produced five good average crops of firm heads. The Indiana muck on the contrary grew only one crop, small in yield and inferior in quality. The chemical analysis indicated that the Indiana humus or peat was as abundantly supplied with plant foods as the New Jersey material. Yet the cultural results varied widely.

When the test for soluble humus was supplied, the New Jersey peat gave a dense, opaque, black liquid, whereas the Indiana product showed no more soluble humus than an ordinary garden soil containing 4 or 5 per cent of humus. This would seem to indicate strongly that chemical analysis alone does not tell the story.

Chemical results in agriculture are of value only in so far as the laboratory findings tell the tale of the actual field test. Seemingly, the solubility test of the chemist is his more indicative analysis when it more nearly reveals the potential possibilities of the muck soil than the summation of total plant foods.

Through the cooperative efforts of the American Peat Society and the United States Department of Agriculture,

much has been accomplished to awaken the layman and the upland farmer to the fact of the diversity of our peat and muck deposits. Much has been done to show the value of such organic matter as an indirect rectifier of the physical condition of our heavy soils. Experiments have demonstrated the direct value of muck and peat as fertilizers. But here again our insecure standards of comparing mucks preclude any careful estimating of the fertilizing value of a given deposit of muck or peat.

Just as truly as the native flora of the upland soils afford a good clue to their productivity, so with the muck soils natural vegetation reveals many secrets. Perhaps an inventory of the crytogamic flora of muck and peat soils would give an even better indication of their real worth. Microorganisms are rather sensitive to environmental factors, and a greatly different type of humus is formed in a warm, well-aerated deposit than in a cold, water-logged one. The change from alkaline to acid reaction means that the bacteria become supplanted by fungi. It is rational to presume, therefore, that the type of organisms effecting the decomposition will modify greatly the character of the end product.

It would not require a lengthy consideration to convert the uninitiated layman to the knowledge that a muck soil which is being tilled and cropped represents a safer source of available fertility than an acid, water-logged muck whose flora consist of rushes, reeds and cat-tails. This later type of organic residue used as a fertilizing material may not only be inert, but actually detrimental to vegetation.

It would seem, therefore, that, for his own protection, the layman purchasing peats and mucks for fertilizing purposes should be educated to recognize the inherent differences in the commodities offered him.

Most of us have an abundant faith in muck and peat as a soil amendment and fertilizer. Dr. Milton Whitney, in United States Department of Soils Bulletin 55, opened the horizon for just such a material. After 100 comparative cultural tests of organic and of mineral fertilizers in which the organic materials gave the better results in 96 cases he concludes: "It would appear from the foregoing that the ideal fertilizer of the future will be organic, provided that such material can be found in sufficient quantity and produced at a sufficiently low cost and less bulky than stable manure for shipment." Dr. Whitney's statement indicates the growing importance of such material and the added necessity for some standard of value for the protection of the buyers.

Water content alone is a simple but commonly overlooked source for exacting prices out of proportion to the actual value

of the material. Some mucks are being sold that analyze as high as 82 percent moisture. Paying freight on water is not going to enamor commercial muck and peat to the buying public.

I have briefly outlined some of the ways in which the whole humus, muck, and peat uncertainty can be lessened, how the outlook can be broadened, and how the different grades of materials can be standardized.

In conclusion permit me to again call four considerations to mind:

First: Humus for agricultural or landscape work should preferably be taken from muck soils of tried and proven productiveness. By such practice poisonous toxins, if present, are given opportunity to become oxidized.

Second: Although straight nitrogen content is not an infallible criterion, still a high percentage of this essential element is desirable. Not only should the nitrogen content be high, and in available form, but the material should be properly balanced by the addition of potash and phosphorus salts if necessary.

Third: The mechanical condition of humus should be such as to permit ready incorporation of the material with heavy upland soils. Fineness of division is of equal importance from the chemical standpoint, as the smaller the particles, the greater is the surface exposed to solvent action. Guarding against excessive moisture content will mean a more favorable attitude on the part of the purchasing public to the whole field of humus preparations.

Fourth: A safe criterion for judging the favorable nature of a humus preparation is the readiness with which the beneficial forms of soil bacteria make it their habitat. If the important soil organisms such as the legume bacteria (B. radicicola) and the independent nitrogen-fixing bacteria (Azotobacter) are capable of persisting in the humus, it is safe to assume that such a material is in the proper state for admixing with any soil. Not only for the safety in judging the material, but also for the favorable results attendant upon their presence, I believe that any muck soil should be so amended that the beneficial bacteria are able to thrive and multiply therein.

It is the hope of the writer that he may have suggested some few points that will tend to eliminate false impressions and deceptions and enable the buyers to obtain genuine soil organic matter, available for plants and free from the objectionable features of water-logged condition and inert ingredients.

Four features present themselves therefore to me as avenues for properly judging the manurial value of muck and

peat. (1) Whether it is tilled and productive in its natural bed. (2) Its reaction and freedom from excess moisture. (3) Its chemical and biological analysis, whether high in nitrogen, whether the other elements are properly balanced, and proper bacterial flora prevail. (4) Solubility.

PEAT FOR FUEL AND DISTILLATION.

(E. A. Paterson, Br. Pat. 12003, 1915.)

This patent relates to improvements in processes for the preparation of peat for fuel, or for destructive distillation and carbonization in which an alkali is first added to the peat to neutralize its acidity and then a suitable silicate before it is dried for use, and consists in first treating the peat to remove about 20 per cent of the superfluous water therefrom, by means of a press or other apparatus, or by heat, before the peat is pressed. The resulting material may be then disintegrated, and, for the purpose of neutralizing the acids, if any, contained therein, a suitable amount (say about 2 per cent) of alkaline material may be added and mixed therewith such as an alkaline earth compound, for instance, carbonate of lime. The next step is to add 1 to 3 per cent of an alkali-metal silicate, such as silicate of soda, either as a liquid which is of a gravity of about 80° Twaddell, or as a dry soluble powder. The material is then intimately mixed in a pug mill or the like, and after being moulded into brick or other suitable form it is dried, preferably in the air, until 50 to 60 per cent of the remaining water is driven off. The operation can be completed or facilitated by passing the bricks, etc., through any suitable or known form of drier at a comparatively low temperature. By this driving process the combined water is freed by the action of the silicate of soda in the presence of the carbonic acid, and the resulting product when completely dried takes th eform of a hard black mass which is thus obtained without the use of pressure, thereby dispensing with an expensive step in the manufacture of peat for fuel, and its preparation for retorting. To economize in the use of the silicate of soda it may be partly replaced by boring, with or without calcium chloride. For instance, 1 to 3 grams of boracic acid is dissolved in 100 c.c. of hot water and 1 gram of calcium chloride is dissolved in this solution. Four c.c. of this solution is stirred into 130 c.c. of silicate of soda solution of 50° to 55° Twaddell, and slightly heated: borate of soda, silicic acid and calcium hydroxide being formed in the solution of silicate of soda.

Influence of Barnyard Manure and Water Upon the Bacterial Activities of the Soil

By J. E. GREAVES and E. G. CARTER

(Jour. Agri. Res., vol. 6, 1916, p. 889.)

A calcareous soil kept in pots with varying amounts of manure and different percentages of moisture gave on bacteriological analyses at the end of four months the following results:

The temperature of the manured and unmanured averaged practically the same for the period, but the temperature of the soil with 12.5 per cent of water averaged 1° C. higher than did soils with 22.5 per cent of water. The greatest number of organisms developed on synthetic media from the soils receiving the greatest quantity, 25 tons, of manure. There were more colonies developed from the soil receiving 12.5 per cent of water than from any of the other soils receiving higher quantities of water.

The ammonifying powers of the soil increased with the manure applied up to 25 tons of manure per acre, but the greatest increase per ton of manure was obtained in soil receiving 5 tons.

The ammonifying powers of the soils increased as the water applied increased until 20 per cent of water was applied. The ammonifying powers of soil receiving 22.5 per cent of water were not as high as were those of soil receiving 20 per cent of water. The greatest increase per unit of water applied was when the water was increased from 12.5 to 15 per cent of water.

The nitrifying powers of the soil increased as the manure and water applied increased up to 25 tons of manure and 22.5 per cent of water.

The nitrogen-fixing powers of the soil were greatest in those pots receiving at the rate of 10 tons of manure per acre. Increasing the water above 12.5 per cent but not above 22.5 per cent slightly increased the nitrogen-fixing powers of the soil. Nothing in the results indicated that the application of manure up to 25 tons per acre and of water up to 22.5 per cent caused dentitrification in the soil.

Bacteriological analyses of fallow field soil receiving none, 5 tons, and 15 tons of manure per acre and receiving none, 5

inches, 10 inches, 20 inches, 30 inches, and 40 inches of irrigation water gave the following results.

The maximum number of bacteria were obtained from the soil receiving 15 tons of manure. The application of irrigation water up to 20 inches increased the bacterial count, being most noticeable in the soil receiving the greatest quantity of manure.

If the ammonifying powers of the unmanured soils are considered as 100 per cent and the unirrigated as 100 per cent, the manured and irrigated soils then become, with 5 tons of manure, 147 per cent; with 15 tons of manure, 188 per cent; 5 inches of water, 106 per cent; 10 inches of water, 117 per cent; 20 inches of water 108 per cent; 30 inches of water, 106 per cent; and 40 inches of water, 108 per cent. Large quantities of irrigation water produced the greatest depressing effect in the presence of 15 tons of manure per acre.

The application of manure to a soil increases its nitrifying powers. The application of irrigation water to a fallow soil apparently depresses its nitrifying powers.

Fewer organisms develop on synthetic agar from a cropped than from a fallow soil. The application of manure to a cropped soil increases the bacterial count of the soil. The greatest number of organisms developed from the soil receiving 10 inches of irrigation water.

The ammonifying powers of the cropped soils were slightly lower than similarly treated fallow soils. The application of 5 and 15 tons of manure per acre to a soil increases the ammonifying powers of the soil. The application of irrigation water up to 30 inches increases the ammonifying powers of the soil. The greatest increase resulted in those soils receiving 15 tons per acre of manure. The application of 40 inches of irrigation water to corn land, especially to that receiving 15 tons of manure per acre, depresses the ammonifying powers of the soil.

The nitrifying powers of fallow soil were higher than similarly treated cropped soils. The application of manure to a cropped soil greatly increases its nitrifying power. The application of irrigation water up to 30 inches, especially to a soil receiving 15 tons of manure per acre, greatly increases its nitrifying powers.

There was found to be a direct relationship between the bacterial count, the ammonifying powers, the nitrifying powers, and the crop produced on a soil receiving no manure, 5 tons and 15 tons of manure per acre.

A close correlation was also found to exist between the bacterial activities of soil receiving varying amounts of water and crop produced upon the soil.

Bacteriological Studies of a Soil Subjected to Different Systems of Cropping After Twenty-five Years

By P. L. GAINEY and W. M. GIBBS

(Jour. Agri. Res., vol. 6, p. 953, 1916.)

(1) The agricultural methods practiced upon the plots under study have brought about marked differences in the number of organisms contained in the soil, at least those capable of developing under our experimental conditions. The soil under continuous corn and wheat contains, in the absence of any additions of fertilizers or manure, relatively low numbers of bacteria. In the presence of manure, continuous corn and wheat soil contain relatively high numbers, manure having a much more marked effect upon numbers here than under the other crops studied.

(2) The agricultural practices under study have, so far as we can detect without experimental methods, produced no appreciable effect upon the ability of the soil and its organic life to liberate ammonia from cottonseed meal.

(3) The ability of the soil complex to oxidize ammonia nitrogen to nitrate nitrogen has been materially altered by the methods under study. This we believe to be due in part to physical and chemical changes in the soil and in part to biological changes. Continuous corn and wheat with no additions of manure or chemicals have brought about a relative low oxidizing power in the soil complex. The addition of manure materially raises the oxidizing power, especially under continuous corn and wheat. The addition of commercial fertilizer brings about a condition similar to that of manure, though perhaps less marked.

LIFE CYCLES OF THE BACTERIA.

By F. Lohns and N. R. Smith.

(Jour. Agri. Res., vol. 6, 1916, p. 675.)

A comparative study of 42 strains of bacteria has shown that the life cycles of these organisms are not less complicated than those of other microorganisms. As representatives of

practically all groups of bacteria have been tested and all, without exception, behaved essentially in the same manner, in all probability analogous results may be expected with all species of bacteria.

All bacteria studied live alternately in an organized and in an amorphous stage. The latter has been called the "symplastic" stage, because at this time the living matter previously inclosed in the separate cells undergoes a thorough mixing either by a complete disintegration of cell wall, as well as cell content, or by a "melting together" of the content of many cells which leave their empty cell walls behind them. In the first case a readily stainable, in the latter case an unstainable "symplasm" is produced.

According to the different formation and quality of the symplasm the development of new individual cells from this stage follows various lines. In all cases at first "regenerative units" become visible. These increase in size, turning into "regenerative bodies," which later, either by germinating or by stretching, become cells of normal shape. In some cases the regenerative bodies also return temporarily into the symplastic stage.

Besides the formation of the symplasm, another mode of interaction between the plasmatic substances in bacteria cells has been observed, consisting of the direct union of two or more individual cells. This "conjunction" seems to be of no less general occurrence than the process first mentioned. The physiological significance remains to be studied.

All bacteria multiply not only by fission but also by the formation of "gonidia;" these usually become first regenerative bodies, or occasionally exospores. Sometimes the gonidia grow directly to full-sized cells. They, too, can enter the symplastic stage. The gonidia are either liberated by partial or complete dissolution of the cell wall or they develop while still united with their mother cell. In the latter case the cell wall either remains intact or it is pierced by the growing gonidia, which become either buds or branches.

Some of the gonidia are filterable. They also produce new bacteria either directly or after having entered the symplastic stage.

The life cycle of each species of bacteria studied is composed of several subcycles showing wide morphological and physiological differences. They are connected with each other by the symplastic stage. Direct changes from one subcycle into another occur, but they are rather rare exceptions. The transformation of spore-free into spore-forming bacteria seems to be dependent on the conditions acting upon the symplasm and regenerative bodies.

The discovery of the full life of cycles of bacteria may be helpful in many directions. Systematic bacteriology now can be established on a firm experimental basis. Physiological studies will win considerably in conformity and accuracy when connected with morphological investigations along these new lines. Several problems in general biology are brought under more promising aspects. Agricultural bacteriology and medical also will derive much benefit.

BACTERIZED PEAT

The Problem in Relation to Plant Nutrition

By PROF. W. B. BOTTOMLEY, M. A.

(Abstract from Jour. Soc. Chem. Ind., vol. 35, 1916, p. 871.)

The attempts that have been made in the past to increase the fertility of a soil by inoculating it with beneficial bacteria have proved abortive, probably because the investigators made use of a liquid culture medium. The remarkably stimulating effect of soil humates upon the nitrogen-fixing bacteria was established some time ago, and efforts were accordingly made to discover a solid medium rich in soluble humates. After much searching, natural peat, transformed by subjecting it to the action of certain aerobic organisms and sterilized at 26° C., furnished the neutral medium required. The product obtained by treating peat with alkalies is also rich in soluble humates, but it is useless as a medium for the culture of azotobactor, and it does not contain the fertilizing products of bacterial activity that are found in the bacterized variety. Thus, when azotobacter chroococcum was cultivated in Beijerinck's medium containing an aqueous extract of the alcoholsoluble constituents of alkali-treated peat, and of bacterized peat, the nitrogen fixation in the latter was over seven times greater than in the former, and the nitrogen fixed both in the raw-peat extract and in the alkali-treated extract was less than that which accrued in the normal culture solution. Some extensive experiments with bacterized peat were carried out in 1913, 1914 and 1915 at Kew Gardens. Eleven different sorts of garden plants were selected, and there were four series of twelve plants of each kind, three of which were potted up in loam, sand, and varying proportions of bacterized peat, and for the fourth a compost of loam, leaf mould and sand was used. At the end of the experiments the curator of the gardens reported that: "In a properly constituted soil, bacterized peat is capable of working a change in its productivity which, after a long experience with plant soils and plant foods, I am in a position to say, is very extraordinary. I have never seen anything to equal it."

The experiments at Kew led to the discovery that the water-soluble extract of bacterized peat contains a constituent of remarkable fertilizing power, which is probably allied to the animal vitamines, for, like these, it is precipitated by phos-

photungstic acid and is active in very minute amounts. (For the preparation, etc., of the phosphotungstic and silver fractions of the alcohol-extract of bacterized peat and their influence on wheat seedlings see Roy. Soc. Proc., vol. 88, B, 1914, pp. 237-247. The stimulating effect of such "auximones" has been studied further on the common duck-weed (Lemna minor) in water culture solution. Thirty of these plants were grown in each of three dishes containing respectively, (A) 600 c.c. of Detmer's complete culture solution prepared with twice-distilled water, (B) the same with the addition of the decomposed phosphotungstic acid fraction of bacterized peat in the proportion of 17 parts of dry substance per million of solution, and (C) the same plus the silver-baryta fraction in the proportion of 0.35 parts per million. The number of plants was counted weekly, their area was measured or estimated, and the solutions were renewed twice weekly during 15 weeks. Owing to the rapid multiplication of the plants in B and in C they had to be divided into two parts on several occasions, and one-half discarded, and at the end of the experiment the number actually in the dishes had to be multiplied by 256 to obtain the number corresponding to the original thirty. The growth was fairly uniform for the first five weeks, although from the beginning the area of the plants in A was much smaller than that of the plants in other liquids. Thereafter the development of the former was much slower, and at the finish they were in a moribund condition. After 15 weeks, the number of plants in A was 143,104; in B 416,000; in 299,520; and the average area of the leases was 0.78, 3.99, and 3.37 sq. mm., respectively. That the increased surface development of the plants treated with auximones had not been obtained at the expense of the plant structure was proved by comparing the ratios of the areas of an equal number of plants in three series with the ratios of their dry weights. The areas of 100 representative plants in A, B, and C were as 1:5.1:4.3 and the corresponding dry weights as 1:7.1:5.7. The differences in internal structure between the control plants and those with auximones were very marked. In the former the air spaces were large and the individual cells small, the nuclei were ill-developed, and nucleoli were not observed; in the latter, the tissue was compact, the cells large, the protoplasm dense, and the large nuclei contained a well-defined nucleolus. It is suggested that the specific function of auximones may be to stimulate in the nutrition of the cell nucleus.

Bacterized peat is essentially a humus manure, and it can not be expected to give striking results when applied to soils already rich in organic matter. Thus, at the Midland and

Dairy Institute, a dressing of 7 cwt. of bacterized peat per acre gave no results on wheat, hay and potatoes, as the land had also received 15 tons per acre of farm-yard manure. On the other hand, large-scale experiments on land at the Hampshire County Council Farm Institute, Sparsholt, Winchester, which had previously borne potatoes, and had only received dressings of superphosphate and ammonium sulphate at the rates of 2 and 1 cwt. per acre respectively, gave most encouraging results with potatoes when dressed with 15 cwt. per acre of bacterized peat. Seven different varieties of potato were grown, and in every case an increase over the control field was observed. These increases were very great—88.3 and 91 per cent in two cases, and the average crop increase was 2 tons 12 cwt. per acre. The price of bacterized peat is expected to be about $10 per ton.

EXTRACTING KAURI GUM OIL IN NEW ZEALAND.

A company has been organized to extract kauri gum oil from peat taken from the swamps in the northern part of the North Island, where kauri gum has been mined for many years.

Some years ago, a company was formed for this purpose, machinery was installed, and the plant was worked for some time, but not with favorable results, as the methods adopted and the machinery installed were not well suited for the work, so it was given up for a time.

It is claimed that the peat yields 20 to 30 gallons per ton, of which about 25 per cent resembles gasoline or benzine, which is being used for motor cars and launches at this time. The remainder contains some 28 different kinds of heavy oils, some of which make exceptionally good varnishing material.

It is stated that in the north of this island are found extensive beds containing much fine kauri gum particles, and are rich in materials producing this kauri gum oil, as well as kauri gum that may be extracted from the deposits.—Consular Report.

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Nitrogen in Peat

It is possibly only during the past decade that the chemistry of the soils has begun to be comprehended. Much still remains to be known, yet we are now beginning to see light through the complex set of compounds present in soils. Until a few years ago, on account of the lack of scientific knowledge regarding the nitrogen in peat, it was considered by agricultural scientists, especially agricultural experiment stations, as of little or no value. Now, however, the agricultural experiment stations are waking up to the latest value of peat and its contents. Valuable publications on this subject have appeared in the past few years, outlining the chemistry of nitrogenous products in soils, especially peat. We refer to works by Shorey, Schreiner and Shorey, Jodidi, Lathrop and Brown, Kelly and Thompson, Potter and Snyder, Robinson, and others. The chief investigations have been conducted by Oswald Schreiner and his colleagues, Shorey, Lathrop, Walters and Wise. Lathrop recently has collected material abstracted in the following paragraphs.

The lack of progress in this field of research has been due in no small measure to the fact that the biochemistry of the products of plants and animals, which eventually go to form the organic substances of soils by processes of decay, was itself so imperfectly understood. A contributing cause probably lay also in the fact that, while organic matter, or humus of soils was known empirically to be of agricultural value, the investigations as to its more exact chemical nature were considered to be of greater theoretical than practical importance as compared to other soil studies, and therefore investigations concerning the nature of humus were often of a purely incidental nature.

It is obvious that many procedures which are the every-day practice of the farmer, such as drainage, irrigation, mulching, inoculation with bacteria, and addition of fertilizers and stable

manures all exert more or less influence on the course of the chemical changes taking place in the soil. It is also equally obvious that there can be no intelligent chemical control of any process unless the chemical nature of the materials involved is thoroughly understood. It therefore became essential to make a systematic chemical and biochemical study of the organic matter of soils. With no established facts and no methods of attack worked out, progress was necessarily slow at first, but gained speed with each compound isolated and identified, until now there have been isolated from soils about 50 definite organic compounds. An idea of the diverse chemical nature of these may be obtained from the fact that representatives of the following large classes of organic compounds have been isolated from soils: Acids of both the aromatic and alipathic series, higher alcohols, aldehydes, hydrocarbons, carbohydrates, resins, esters, glycerides, glucosides, amino acids, nucleic acids, proteoses and peptones, amines, purine bases, pyrimidine bases, various other nitrogen and sulfur-containing compounds, etc. These compounds may be considered to cover fairly well the principal classes of compounds encountered in other lines of biochemistry, and therefore the knowledge in regard to the chemical relationships, origin and processes of change accumulated in such other lines can be directly applied to the understanding of the biochemical changes in soils and the constitution of soil organic matter. Thus it has been possible to throw much light upon the biological and biochemical changes in soils so that the old views of soil organic matter, soil humus and the process of humification have been either radically modified or completely overthrown.

The quantity of total nitrogen in soils varies from a few hundredths of per cent in light sandy soils to 0.5 per cent or more in rich heavy loams. Peats and mucks, which from the agriculturalist's viewpoint will be considered as soils high in organic matter, contain from 0.5 per cent of total nitrogen in the case of light mucks to about 4 per cent in the case of some peats. Of the total nitrogen in soils, normally only about 0.1 per cent exists in the form of ammonia or ammonium salts and about 1 to 2 per cent in the form of nitrates. The remaining portion of the total nitrogen, 97 to 99 per cent exists in organic combination. In view of the fact that the ultimate source of the organic constituents found in soils is the débris of plants or animals and that organic nitrogenous compounds are a constituent part of all protoplasm, a comprehensive conception of the more immediate sources of the nitrogenous matter of soils may best be obtained by a consideration of the sources of soil organic matter in general. The organic matter of soils may be

divided into two general classes—in living and nonliving. To the former class belong earth-worms, beetles, larvae, molds yeasts, bacteria, protozoa, higher fungi algae roots and rootlets of the higher plants. The greater portion of the organic matter consists, however, of nonliving matter.

This organic matter may be conveniently subdivided into four classes:

(1) The materials furnished by the recent generations of living matter in the soil, or by recent additions of organic manures, fertilizers, or plant débris, and other extraneous matter, which has not yet been in the soil for a long enough time to decompose and still retains to a very great extent the physical structure of its former self. However, chemical changes incident to the death of the plant and animal cells have already occurred in this material, such, for example, as those brought about by the interaction of soluble compounds, nonreactive in the living cell, or by autolysis due to the enzymotic action within the dead cell. These processes may produce both lysis and synthesis and are probably of considerable importance in the transformation of organized material into humus.

(2) Material which has either partly or wholly lost all vestige of its original structure. Such substances have already undergone considerable chemical change either by direct oxidation or reduction, or by chemical changes produced either by the organisms of the soil, or by other agencies. To this class of organic soil material belong all compounds intermediate between the complex organic substances which composed the original plant or animal materials entering the soil and the final products of their decay. This class makes up the major portion of the organic matter of ordinary agricultural soils.

(3) Substances which decompose only slowly in the soil, or not at all. In this connection it is interesting to note that Schreiner and Brown (1912), in investigating this resistant class or organic material, discovered in many soils particles of coal, lignite, charcoal, remains of insects, resins, etc. There is also some evidence that to this class of more or less organized substances there should be added certain very complex chemical compounds such as those obtained synthetically by Maillard (1913) through the interaction of certain carbohydrates and amino acids, compounds which seem to be resistant to chemical treatment.

(4) The synthetic products of the life processes of the micro-organisms in the soil, both those that fix atmospheric nitrogen and those that synthesize into more complex compounds, such as proteins and nucleoproteins, the nitrogen which

is present in the soil in the simpler forms of ammonia, nitrates, amides or amino compounds.

The organic matter of soils must be considered to be material in a dynamic state. It is not only the product of change, but at the same time it is continually in a state of change. Two processes are continually going on in soils, one which is essentially lysis, the breaking down of the complex compounds into the simpler by the processes of hydrolysis, oxidation, reduction, etc., and the other synthesis, or the building up of complex compounds from the simpler ones.

The factors operative in these changes constantly taking place in the soil are many and varied. Possibly the most important are the micro-organisms of the soil, which find the organic matter a favorable medium for growth. No fact, however, concerning micro-organisms is probably better established than that they are profoundly influenced by the nature of the medium, not only in their habits of growth but also in the products which they produce. Such factors as moisture, aeration, acidity or alkalinity, the nature of the organic matter, the mineral constituents of the soil, or the addition of fertilizers will, therefore, exert a marked influence, not only on the types of the active micro-organisms, but also on the nature of the changes they produce in the soil. At the same time these various factors influence also the purely chemical changes taking place in the soil; that is, the course of the decomposition will be different according to the factors concerned in the decay. When certain conditions predominate, the compounds produced in the soil will be normal and beneficial. If however, another set of conditions prevails the compounds may be abnormal and harmful. In soils there is a balance of the beneficial and harmful factors, soil fertility or infertility being the resultant of the two groups. As one or the other of the groups gains ascendency, the fertility is raised or lowered, as the case may be.

How the War Has Helped Agriculture in General and Peat Industry in Particular

By H. B. FULLERTON

Although I am neither a deep thinker nor a lecturer, when the Society called on me for a paper, I selected as the most vital twentieth century subject the effect of the great war on the peat industry. I trust that my statements will stand inspection.

Hardly had the war of destruction gotten well under way in Europe before the agricultural world began to receive veiled hints that chemical fertilizers would increase considerably in cost. A little later, inspired press notices appeared, calling attention to the fact that as potash either as suphate or chloride would be limited in quality, mixed chemical fertilizers would contain smaller potash percentages. These notices were followed at frequent intervals with suggestions regarding temporary substitutes for potash which had long been held an absolute annual necessity for various kinds of plant growth. Strangely enough, and yet logically enough, echoes of these inspirations began to appear in Government and State publications, and a marked revamping of the stock lectures and other teachings followed closely.

Propagandas pushed with the vigor readily seen when the long green exists in bales were modified, side tracked, and otherwise warped in an impossible endeavor to explain why chemicals were still the only thing for the crop raiser even though the said mixtures were devoid of anything but the most homeopathic doses of potash. Then, wonder of wonders! The agricultural press and the general press teemed with exeremely labored explanations that, if potash was lacking, big increases of phosphoric acid or compounded phosphates would serve the agriculturist's purposes. To the financially uninterested but still deeply interested followers of the agricultural profession this new propaganda looked much like a disorderly retreat or at least a complete about face. It junked all the teachings and literature of considerably more than a quarter of a century, and the enigma became unsolvable even to the super-ones credited with possessing the wisdom of the fabled sphinx. Then the warning followed that nitrate of soda would, "on account of war in Europe," soar to prices beyond the reach of fertilizer mixtures, and various substitutes were suggested because they were known through laboratory analysis to contain nitrogen in

some form, some of them such as leather scrap being notoriously chary in giving up nitrogen or anything else of value agriculturally. The most businesslike and most successful agriculturists began for the first time to grow suspicious. The about face was too sudden and they naturally harked back to the successes achieved by their ancestors, even as late as their fathers, and, discovering that record crops in their community had been raised years before the famous Liebig had made the results of his chemical researches known to the world, they also about faced and went back to barnyard manure, sea weed, swamp muck, the turning under of sod, and the application of the shells of the mollusc.

They hoped for at least a fair crop. They were astounded by not only normal but bumper crops in accord with the individual ability to properly cultivate and otherwise care for their plant growth. Others purely as a move for safety used the customary bags of compounded minerals supplemented by barnyard manure or swamp muck and were much surprised to find their crops fully equal to and on the average better than when they had used the mathematically correct proportions so long pronounced the only thing. Unfortunately, however, many stuck to chemical fertilizer alone and their crops ran all the way from near failure to total loss. This sums up the experience of soil tillers in many different sections all east of the Mississippi.

The experiences of 1915 backed up the convincing check experiences of 1916 have accomplished in two years results that would not have been obtained by less than a generation of the most extensive and widespread propaganda through publications official and otherwise and by uniform teaching in the halls of agricultural learning. The net result is the general realization that humus in its varied forms is not alone valuable but most undeniably a crop insurance most pronounced for those crops affected by the dry weeks of the summer.

The American Peat Society therefore will find that instead of peat being the vital item, properly prepared humus will be the most prominent and the most valuable item for its distinguished consideration as the up-keep of soil fertility.

The only real benefit to mankind in general, directly due to the horrible butchery of mankind in Europe is the enforced return to the natural normal practices of soil tillers of the past who kept their acres up to full productivity by the use only of humus-supplying materials and lime.

This pushes into insignificance the gain of mere dollars by other far less important industries and professions in the United States.

CARL G. KLEINSTUECK.

In our last issue it was our sad duty to announce that our past president, Carl Gotthold Kleinstueck, had departed from our midst. Mr. Kleinstueck was born on May 3, 1853, in Dresden, Germany, where he received his early education and where he learned to become a great lover of nature. He had travelled extensively as is known by those of us who have followed his writings in our Journal, and he was highly respected by all with whom he came in contact.

He came to America in 1880 and settled in Chicago, where he was married in 1883. He moved to Kalamazoo in 1885 and established his permanent home and began the development of a large tract of peat. He was an active and ardent member of the American Peat Society in which he served in several official positions.

He helped form the Michigan State Humane Association, of which he was always a member of the executive board, and served two terms as president. He passed away suddenly on the evening of December 11, 1916, at Melbourne, Fla.

PEAT IN 1915

By James S. Turp.

(Reprint from U. S. Geological Survey.)

Introduction.

The report on peat, published annually in Mineral Resources, was prepared for a number of years by Mr. C. A. Davis, formerly of the Survey but recently of the Bureau of Mines. His death, in April, 1916, was a misfortune to those connected with the peat industry; they lost not only one of the best authorities on peat in the United States but also one of the industry's best friends.

For data used in compiling the present report the author is indebted to the cordial co-operation extended by the producers of peat, for which he expresses his appreciation. The outline used by Mr. Davis has been followed, in general, and liberal use has also been made of the information contained in the reports prepared by him.

Distribution of Peat in the United States.

The distribution of the domestic deposits of peat has been thus described by Davis:

In the United States the regions most favorable for the occurrence of deposits of peat are in the States lying east of about the ninetieth meridian and north of an irregular line following the southern margin of the last or Wisconsin glacial drift. This line runs nearly due east across north-central Iowa, Illinois, Indiana, and Ohio, and, after dipping southward a short distance along the Appalachians, turns northeastward across Pennsylvania and New Jersey nearly to the coast. Peat deposits are also of frequent occurrence in the region extending southward from New Jersey along the Coastal Plain to and including Florida. In the regions of heavy rainfall along the Pacific coast peat deposits occur wherever the drainage is sufficiently interrupted to allow the soil to be flooded or permanently saturated by water. The States known to have the most extensive peat deposits are Florida and those along the northern border as far west as North Dakota.

A map compiled by Davis[2] shows the distribution of deposits of peat in the United States, approximate location of plants for the utilization of peat beds, and other data.

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[1] Davis, C. A., Peat: U. S. Geol. Survey Mineral Resources, 1914, pt. 2, p. 376, 1915.

[2] Davis, C. A., The uses of peat for fuel and other purposes: U. S. Bur. Mines Bull. 16, pl. 1, 1911.

Utilization of Peat in the United States

In spite of the many uses of peat in European countries and of the extensive deposits in the United States, the domestic material has only recently been produced on a commercial scale for any purpose.

PEAT AS FUEL.

Many attempts have been made in this country, with almost uniform lack of success, to manufacture fuel from peat. The reasons for failure of such enterprises have been manifold, but so far as can be determined by careful inquiry the failure has not been caused by inability to sell the product, but generally by other factors, among which may be mentioned, inexperience of operators, inadequate machinery, and lack of sufficient capital.

Robert Beli[1], in a paper read at the eighth annual meeting of the American Peat Society, at Duluth, in August, 1914, describes a process for the manufacture of peat briquets essentially as follows:

To the air-dried peat is added crude oil, dextrine, and lime, and the mixture is compressed into briquets, which are hard, dense, black, durable, unbreakable in transportation, and burn freely with a long, clear flame. * * * *

The process produces an artificial coal yielding 10,000 to 11,500 British thermal units per pound, according to the amount of crude oil added, the cost for binder being only 8 cents per ton, and the cost of the finished fuel being about $1.15 to $2.15 per ton. * * *

The briquets produced by the Herebein process have been thoroughly examined and passed on by engineers the world over, and I feel that in presenting this fuel I lay before you a form of peat fuel that the peat industry has dreamed of and has striven to produce in this country and in Europe.

The company interested in this process reported no production in 1915. They report, however, that plans are made to complete the plant so that operation may begin early in 1917.

In 1915 no peat-fuel plants were reported in operation, whereas in 1914 there were four such plants which had an estimated production of 1,925 short tons of air-dried machine peat. Of the plants reporting in 1914, one has been absorbed by another concern that is installing an extensive plant with a view to operation during the latter part of 1916; another expects to resume operations in the summer of 1917; and the other two have merely reported no production. It seems likely, therefore, that there will be little or no domestic peat produced for fuel in 1916, but that

[1] Blei, Robert. The Herbein process for making briquets from peat, petroleum, and binder: Am. Peat Soc. Jour., vol. 8, No. 4, pp. 83-85, October, 1915.

1917 will witness a resumption of peat-fuel operations in this country.

PEAT AS FERTILIZER AND FILLER.

The most successful industry based on peat so far attempted in the United States is that of preparing peat for use as a fertilizer or as filler for chemical fertilizers. Black, thoroughly decomposed peat is most satisfactory for all fertilizer uses, as such peats are generally healthier and more compact and contain more nitrogen and less fibrous material than the brown types. Some of the peat sold during 1915 for direct use as fertilizer was enriched by the addition of beneficial soil organisms.

The production of peat for fertilizer and fertilizer filler during 1915, as reported, was 38,304 short tons valued at $258,447, as compared with 37,729 short tons, valued at $249,899, in 1914. The selling prices given varied widely according to the grade of the product, the used to which it was put, the quantity and quality of the materials added, and the size of the selling unit. The lowest price per ton reported was $3, the highest $16, and the average $6.75.

The following table shows that in only two years, 1911 and 1912, since these figures were first published by the Geological Survey has the production of peat for fertilizers been greater than in 1915. The most striking feature, however, is that although the production in 1911 was nearly 13,500 tons in excess of that in 1915, the value in 1915 was more than $1,000 in excess of the value in 1911.

	Quantity (short tons).	Value.		Quantity (short tons).	Value.
1908	23,600	a$121,210	1912	41,080	$186,022
1909	26,768	118,891	1913	28,460	169,600
1910	37,024	140,209	1914	37,729	249,899
1911	51,733	257,204	1915	38,304	258,447

a Estimated.

Peat used for fertilizers produced in 1908-1915.

Requests for information regarding the use of peat strictly as a fertilizer should be addressed to the Chief, Bureau of Plant Industry, Washington, D. C.

PEAT LITTER.

No peat litter has been produced in the United States for several years. As in previous years, however, a certain quantity was imported in 1915 under the name of "peat moss." The entire importation was 7,514 short tons, valued at $48,142 or $6.41 per

ton an increase in value per ton over 1914 of $0.61, but a decrease in total quantity of 2,407 tons and in total value of $9,400.

OTHER USES OF PEAT IN 1915.

Only two other uses of peat were reported by producers in 1915—as an ingredient of stock food and as used by florists. The quantity shipped for the latter use was reported by the producer with the peat for fertilizer. The single firm that has for some years reported production of peat for making paper failed to answer inquiries for 1915, and the firm that reported peat for mud baths in 1914 gave no such production in 1915.

Two firms reported the production of peat for stock food, the total amounting to 3,980 short tons, valued at $30,090, or an average price of $7.56 per ton. It is stated by one of the producers that the results obtained by the use of peat in such foods have proved very satisfactory, the peat acting as a tonic and a corrective. The kind of peat so far used in this country for the purpose is of the black, well-humified type.

PRODUCTION.

During 1915 no new processes or machinery for preparing peat were reported to have been commercially tried in the United States, but several firms reported additions and improvements to their plants some with a view to increased production. The whole number of plants reporting production was nine, all of which sold peat for fertilizers and two of which also sold peat for stock food. Seven firms that furnished data for 1914 furnished none for 1915, and two firms reported that were not represented in 1914. Of the seven not reporting production in 1915, four are the peat-fuel plants, one is the paper manufacturer mentioned above, one has discontinued the production of peat, and the other plant was sold.

The nine plants known to be at work during the year were distributed as follows: Massachusetts, 1; New York, 1; New Jersey, 3; Pennsylvania, 1; Florida, 1; Illinois, 2.

The quantity of peat products made and used in the United States in 1914 and 1915, so far as these have been reported, are given below. In the statement for 1915 the peat sold for fertilizers is given under one heading, as from the reports submitted it is impossible to separate definitely the quantity sold for use as direct fertilizer from that sold for use as fertillizer filler.

Peat produced, imported, and consumed in the United States in 1914 and 1915.

Use.	Production		Imports		Consumption	
	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.
1914.						
Fertilizer filler	22,767	$136,994	.....	.....	22,767	$136,994
Fertilizer	14,962	112,905	.....	.....	14,962	112,905
Fuel	1,925	6,540	.....	.....	1,925	6,540
Miscellaneous *a*	7,439	53,253	.....	.....	7,439	53,253
Peat moss litter	.....	.....	9,921	$57,542	9,921	57,542
	47,093	$309,692	9,921	$57,542	57,014	$367,234
1915.						
Fertilizer and fertilizer filler	38,304	$258,447	.....	.....	38,304	$258,447
Stock food	3,980	30,090	.....	.....	3,980	30,090
Peat moss litter	.....	.....	7,514	$48,142	7,514	48,142
	42,284	$288,537	7,514	$48,142	49,798	$336,679

a Only 1 producer of peat for stock food, mud baths, and paper pulp.

Investigation of Peat Bogs in Canada, 1915

By A. Anrep, Peat Expert

In accordance with instructions, a survey of peat bogs was carried on during the season of 1915, in order to determine the extent, depth and different qualities of the peat contained in the various bogs. This investigation started late in June, when the writer left Ottawa with Mr. E. V. Gage as a temporary assistant, to perform the field work which was carried on during July, August and part of September.

The following statement briefly summarizes the results of the season's investigation:

(1) Moose Creek peat bog is situated about 1½ miles northwest of Moose Creek, about 2 miles northeast of Casselmen in the townships of Roxborough, South Plantagenet and Cambridge, counties of Stormont, Prescott and Russel, province of Ontario.

The total area covered by this bog is approximately 12,543 acres, with varying from 3 to 17 feet.

The Grand Trunk railway traverses the center of the bog.

(2) Westmeath peat bog is situated about 1 mile south of Westmeath, 1¼ miles north of Beachburg, township of Westmeath, county of Renfrew, province of Ontario.

The total area covered by this bog is approximately 2,840 acres.

The Canadian Northern railway runs about 1¼ miles south of this bog.

(3) Meath peat bog is situated about ½ mile west of Meath station in the townships of Westmeath and Stafford, county of Renfrew, province of Ontario. The total area covered by this bog is approximately 1,695 acres.

(4) An investigation was also commenced on the Snake River peat bog. This bog is situated about one-half mile south of Snake River station on the Canadian Pacific railway in the township of Westmeath, county of Renfrew, province of Ontario, and follows in a narrow strip each side of the river towards Osceola. This investigation was not completed.

Inasmuch as a systematic investigation of a peat bog occupies considerable time, and as the appropriation for the season's investigations had been decreased to less than one-half the amount granted for previous years, it was found impossible to investigate more than three bogs.

The total area investigated in Ontario for the season of 1915 comprised approximately 17,078 acres.
(Reprint from Summary Report, Dept. Mines, Ottawa, Can.)

PEAT IN FRANKLIN COUNTY, FLORIDA.

A soil survey of this county by Charles N. Mooney and A. L. Patrick, recently published by the U. S. Bureau of Soils, is of interest on account of the occurrence of peat there.

Franklin County is situated near the center of the western extension of Florida, on the Gulf coast. It consists of a mainland area with a number of outlying islands. It has a land area of 541 square miles, or 346,240 acres.

The county is within the low coastal region bordering the Gulf of Mexico. The surface is a flat, featureless plain, and only along the coastal borders and up the main streams is there any topographic relief. These borders apparently are higher and are well drained, while the interior of the county is flatwoods country comprising a large number of almost impenetrable bays or swamps. The elevation ranges from about 20 feet above sea level in the northern part of the county to 5 to 10 feet along the coast.

The county is drained by small creeks and branches emptying directly into the sounds and bays or into the larger streams. The Apalachicola, bordering the county on the west, is the main river. New River crosses the county near the center, and the Ochlockonee River forms a part of the eastern border. The small streams are generally sluggish and have swampy borders.

The settlement of this county began early in the last century. The settlers were from nearby Southern States, and the present population consists largely of their descendants. The population is reported in the 1910 census as 5,201, and is largely concentrated in Apalachicola, the county seat, and Carrabelle, the next important town, both of which are Gulf ports. The rural population is small and scattered over the county.

Franklin County is traversed by the Apalachicola Northern and the Georgia, Florida & Alabama railroads. Steamboat lines operate on the Apalachicola River and its tributaries, and coastwise ships furnish water transportation to different Gulf ports.

The climate is mild and is modified by winds from the Gulf. The mean annual temperature is 69.1° F. and the mean annual precipitation 56.19 inches. There is a normal growing season of 310 days, although crops that can withstand slight freezes can be grown throughout the winter.

Agriculturally the county is undeveloped. Lumbering and turpentining are the chief industries, the latter being of greatest importance. Small areas are cultivated to subsistence crops,

including corn, sweet potatoes, and sugar cane, and garden vegetables. There is a small trucking industry to supply the towns and the lumber and turpentine camps. A few cattle and hogs are raised, being grazed in the open range. Dairying is practiced in a small way near Apalachicola. Only 3.5 per cent of the area is reported in farms in the 1910 census, there being a total of 17 farms in the county, with an average size of about 717 acres. Of this land in farms only about 4 per cent is given as improved. Stock raising offers good opportunities, and trucking can be successfully developed.

The soils of the county are of marine sedimentary origin and are predominantly sandy. There are two general groups, the light-colored, well-drained soils and the poorly drained, or dark-colored soils. The former includes those of the Norfolk and St. Lucie series and the latter the Leon, Portsmouth, Plummer and Hyde series, and muck. A large total area of miscellaneous materials is classed with swamp, tidal marsh, coastal beach, and shell mounds.

The muck consists of more or less decomposed vegetable remains resulting from the rank growth and decay of vegetation in the presence of water and under conditions favorable for its accumulation. As found in this county it is black and generally finely divided, although in places it is somewhat fibrous or peaty. Except along the borders, where it adjoins sand areas, most of the muck is practically free from sand, but contains a considerable quantity of silt and clay. In the narrow slough areas on St. Vincent and St. George Islands, however, the muck in places is not over 10 or 20 inches deep and is underlain by gray to white sand, with an admixture of small quantities of sand in the muck.

For the most part the muck is three feet or more in depth. In saw-grass ponds it may be eight feet or more in depth. The typical muck is found in the saw-grass ponds. These ponds are small and are scattered throughout the county. The largest area of muck is along the Crooked River and around Tucker Lake, at the east end of St. James Island. It occupies depressed areas which are little above sea level and are covered by water generally throughout the year.

The only agricultural development on muck is at Eastpoint, where several acres, comprising a number of small saw-grass ponds, have been drained and put under cultivation. Garden vegetables, strawberries, sugar cane and Irish potatoes are grown successfully. Celery does well, and an effort is being made to produce this crop commercially. The muck areas are limed to correct acidity, and applications of potash and phosphoric acid are made. Where these areas can be properly

drained they should prove valuable for the development of trucking.

Muck, Titi Phase.—This phase is shown on the soil map by cross lining. The surface has a thin veneering of partly decayed leaves and twigs, and under this a black muck, containing some sand, silt and clay, is encountered. The fine sand increases with depth, and a substratum of fine sand is found at a depth of four to six feet. Under the immediate surface layer the material in its natural state has a soft, oozy structure, owing to the large amount of moisture present.

The titi phase of muck occurs in small, widely scattered areas the largest being found on St. James Island, near Lanark and Carrabelle, west of Apalachicola and north of Marsh Point. It occurs in low, swamp areas usually bordered by the Hyde fine sand. The drainage is poor, water standing on the surface during the greater part of the year.

The characteristic vegetation is a dense, rank growth of titi, with some cypress and slash pine.

Little of this soil has been cleared, except at Carrabelle, where one or two small patches are used for growing vegetables and strawberries for local use. It is well suited to these crops.

Swamp includes low-lying areas bordering streams. The soil material is variable. It usually is of a mucky to peaty character, though frequently silty. In places, mainly along the smaller streams, clay or even sand material predominates.

The largest areas of swamp occur along the Apalachicola, Jackson, Ochlockonee and Crooked Rivers and their tributaries. They are of value only for their cypress timber, and the gum swamps only as bee pasturage. This latter is of considerable importance, as a number of apiaries are situated near swamps of this character.

The areas mapped as swamp support a growth of water-loving trees and shrubs. They comprise what are known as cypress and gum swamps. In places they support a thick growth of cypress of large size, while in other areas, although the cypress predominates, there is a growth of gum and bay, with some magnolia and hickory in the higher bodies or in small hummocks in the swamps. On the other hand, some areas support a heavy growth of gum, including the different tupelo gums, with a large variety of other trees and shrubs, conspicuous among which are cabbage palmetto, magnolia, bay and myrtle, and a luxuriant growth of ferns. The growth in these swamps is dense. The swamp is covered by water a large part of the year, and especially during flood stages of the streams.

Where the cypress timber has not been removed this land is assessed at $2 an acre.

Tidal marsh consists of the low, flat, mashy areas at the mouths of rivers and along the shores of both the mainland and the islands that are gradually being built up from debris deposited by the tides and the streams. They are subject to inundation by tides or floods, and have a salty or brackish character, depending upon the source of the overflow water. The areas along the sounds are always more salty than those farther up the streams, but all are within reach of salt water.

The material forming these marsh flats is variable; it is usually silty and consists in part of silty muck or silty peat. These areas represent recent soil material still in process of formation. They support a growth of marsh grasses.

The largest areas are those in the delta of the Apalachicola River, up the Jackson River to Lake Wimmico, and in the lower courses of the Ochlockonee, Crooked and New Rivers. Relatively large areas occur also on St. Vincent, St. George and Dog Islands, and narrow strips occur along the shore of the mainland.

The tidal marsh areas are of no agricultural importance, except that they afford some grazing for cattle.

DIRECTIONS FOR PREPARING MANURE FROM PEAT.

The following note has been communicated to the Board of Agirculture by F. E. Weiss, D. Sc., professor of botany in the University of Manchester:

It is not usual to review a publication issued a hundred years ago, but the interest which has been taken in the Manchester scheme for manufacturing bacterized peat may serve as an excuse for drawing attention to a pamphlet published in 1815, and bearing the title, "Directions for Preparing Manure from Peat." The anonymous author had already previously printed and distributed, in the form of a tract, his discovery that common peat was convertible into a putrescent manure, equally powerful as farmyard dung for the cultivation of ordinary crops, giving instructions for conducting and accomplishing the process requisite for that purpose. The author, a large landed proprietor in Scotland, having occasion to scoop out from a hollow a quantity of peat moss in order to provide a space for a small artificial lake, found himself in a difficulty when faced with the problem of disposing of the mass of peat thus obtained, and being of a shrewd and practical turn of mind, he tried a variety of experiments with a view of converting it into a manure. The experiments were undertaken in a truly scientific spirit, with a considerable insight into the nature of peat, and with as good a knowledge as was available at the time of the process of putrefaction as observable in the decay of animal and vegetable matter. Recognizing in the deposits of peat the accumulation of vegetable

matter in a state of partial decay, the author noted that in its natural state further putrefaction was inhibited, and he supposed that this was due to the evolution of tannin and gallic acid which had been detected in it. "Peat," as our author tells us, "when taken out of a bog, is certainly not manure. If dried, it becomes fuel, and so remains if kept dry. But if exposed to the vicissitudes of the atmosphere in our climate, it becomes, in the course of years, a sort of vegetable mould; and if mixed with the soil and cultivated, raises good crops of potatoes and other vegetables."

How to accelerate this process was the object of his experiments extending over six or seven years. He first tried the effect of mixing the peat with substances that would neutralize its acidity, but peat mixed with lime for 12 months and used as a top dressing did no good for several years. He next mixed the peat with various forms of decaying vegetable and animal matter, and found that the putrefaction of these substances was communicated to the peat, setting up fermentative activity indicated by the rise in temperature, and resulting in the production of a rich compost, very effective in the raising of crops. In the earlier experiments he used such substances as the refuse of fisheries, shamble dung, etc., and in 1802 he had already announced a successful experiment by which he produced 10 tons of rich compost from peat made up with shavings of timber and the carcass of a horse, partly with and partly without the addition of some old lime rubbish. The method he advocates in the pamphlet of 1815 as the simplest and most useful to farmers, however, is the mixing of peat with about a third of its weight of ordinary farmyard manure. The peat should be allowed to dry for a few months before carting. Then, after spreading a layer of 6 inches of peat, about 10 inches of dung may be placed above the peat, then another 6 inches of peat, followed by four or five of dung. After a third layer of peat and dung, the whole should be covered with peat, making a heap about 4 to 4½ feet in height. In mild weather, 7 cartloads of tolerably fresh farmyard dung is sufficient for 21 cartloads of peat moss, but in cold weather a larger proportion of dung is required. It is useful to add about half a load of slaked lime, or about a load of ashes, but neither of these is essential. When the compost is thus made up it gets into heat in summer in less than a fortnight. If it gets too hot, it should be watered or turned over, and in doing this a little more peat can be added to the heap. When the heat subsides, it will be found that a very perfect compost has been formed, all the lumps of peat having been broken up. Used weight for weight, it will be found quite as good as farmyard manure.

Peat, made up with sea-weed, heats and appears to undergo the same changes as when prepared with dung. It has proved

equally efficacious in raising wheat, but does not promote such early ripening of the grain. Made up in this way, two natural products which are usually allowed to go to waste may be used for enriching our crops, and where both are easily obtainable, advantage should be taken of their accessibility.

Our author's experiments proved successful, and his directions were circulated by many large Scottish land-owners among their tenants. It would be interesting to know to what extent the practice was adopted, and to what extent it has been kept up in Scotland. The growing scarcity of dung, which is likely to increase with the further development of mechanical methods of traction, may resuscitate this discovery of a bygone age, at all events, in those districts in which peat can be had practically for the cost of cartage. Apart from this possibility, it is not without interest to find that experiments made so long ago as the commencement of the last century showed without doubt that peat, consisting as it does of partly decayed vegetable debris, contains the basis of valuable plant food, and if the latter can be rendered available to plants, may become a useful manure.

In all probability, in the method recommended by our author, the acidity of the peat becomes neutralized by the ammonia contained in the dung, while decay-producing bacteria may percolate into the peat in addition to those normally contained in it, but whose activity is inhibited by the presence of humic acid.

In very much the same way the peat in Chat-Moss has been in the course of years transformed into a rich black soil of great fertility. Drained of its acid water and neutralized with lime, it has been further enriched, both in nutrient matter and in decay-producing bacteria, by the addition of sewage, and has thus been rendered capable of promoting vigorous growth of crops. Now that the Manchester Corporation has undertaken to produce a manure from peat, it is to be hoped that, if it proves successful, it will once more draw attention to the possibilities of utilizing the great peat deposits of the British Isles, which, in this scientific age, should surely not be allowed to remain an unused and, therefore, wasted store of plant-food.

(Jour. Bd. of Agri., Vol. 23, 1916, p. 481.)

A Preliminary Report on Much Humus as a Fertilizer and Carrier of Beneficial Soil Bacteria

By THOS. F. MANNS and JOSEPH M. GOHEEN*

(Reprint of Bulletin No. 115—Delaware College Agricultural Experiment Station).

Within recent years practical agriculturalists over the United States have come to recognize the ease and efficiency with which muck soils lend themselves to the production of truck crops. The utilization of mucks and peats for fertilizer fillers, materials for amending the physical condition of upland soils, and their use as a direct fertilizer has likewise served to bring the consideration of such material to the foreground.

It is recognized also that there may be as much difference between soils of organic origin as between the most diversified of the mineral soils. The commercialization of deposits of different formation has also served to emphasize this point through the highly satisfactory results obtained in some cases and the injurious effects in others.

Micro-biological studies of American soils have been confined almost exclusively to those of mineral origin, but the increasing interest in organic soils and the important role that the micro-organisms play in them make highly legitimate a study of their activities.

The object of these investigations was to determine (1) whether high grade muck or so-called "humus," such as that found in the trucking district in northern New Jersey, when properly inoculated, would carry beneficial soil bacteria, including the nodule organisms for the different agricultural and floral legumes; also whether reinforcement and composting of the muck humus would further increase or favor a beneficial flora. (2) Further, to determine the simplest method of adding such inoculation. (3) To determimne whether one compost may carry the inoculant for all the agricultural and floral legumes at the one time and be sufficiently reinforced and balanced to make a high grade soil inoculator, renovator, stimulant and fertilizer. The work necessitated a study of the flora found in the virgin muck, and the changes brought about by successive years of cultivation, and further, what organisms should be added to make the material a general and beneficial soil inoculant.

*Holder of research fellowship given by the Alphano Humus Co., of New City.

The Status of Legume Inoculation.

It has been known for a number of years that the organism causing nodules on certain legumes would also produce nodules on closely related species; for example the organism producing nodules on white sweet clover (Melilotus alba) and yellow sweet clover (Melilotus officinalis) is the same as that which works on alfalfa. The same organism also works on Indian yellow sweet clover (Melilotus indica), trefoil or black medick (Medicago lupulina), yellow alfalfa (Medicago falcata), burr clover (Medicago denticulata), spotted medick (Medicago arabica), and Trigonella foenum graecum.

It is known that in the clover group the organism which inoculates red, mammoth, white and alsike clovers (Trifolium practense, T. medium, T. alba, T. Tybridum) also inoculates crimson, buffalo, rabbit-foot hop and hop trefoil clovers (Trifolium incarnatum, T. reflexum, T. arvense, T. Agrarium, T. procumbens.)

Likewise the organism which covers the vetch and pea group, covers the plants of the genera Vicia, Pisum and Lathyrus, including many species.

A fourth group may be known as the bean group which covers many species.

At present, soy bean (Soja spp.) and cow pea (Vigna spp.) are apparently distinct, making six specific groups covering our important American agricultural and floral legumes.

Two other groups are those including the lupines and the lotus. M. Klummer and R. Kruger*, two European workers and H. Garman and M. Didlake** of Kentucky have recently published articles showing the groups into which certain of the different legumes fall.

Using this as a basis, we have gathered inoculation representing each of the above groups for the purposes of this work.

Variations in Composition and Flora of Muck and Peat.

The investigations have necessitated the study of an inferior and very acid peat, for a comparison of the acidity, the chemical analysis, and the flora. Such a comparison was made with a peat being used in the vicinity of Sumner, New Jersey, which was quite coarse and poorly decomposed.

Table 1—Comparison of Alphano, New Jersey, muck, with peat from Sumner, New Jersey.

(1)	Alphano, N. J. muck	Sumner, N. J. peat
Lime Requirement (per 2,000,000 lb. acre, air dry basis.)	4200 to 5300 lbs. (CaO)	12,600 to 17,000 lbs. (CaO)
Nitrogen	2.67%	1.3%

(2)		
Humus or soluble Org. matter	26.2 to 29.4	4.3—6.8
Ammonifiers per gram dry basis.	50,000—260,000	33,333
(3)		
Nitrifiers, per gram dry basis.	10,000— 33,000	None.
(4)		
Azotofiers, per gram dry basis.	20,000— 66,000	Trace.
(5)		
B. radicicola, per gram dry basis.	50,000—133,000	Trace.
Various moulds—	50,000—133,000	Trace.

(1) Lime requirement by the saturated calcium acetate method mentioned in a paper read before section C (Chem.) of the American Association for the Advancement of Science, Philadelphia, Pa., Dec. 31, 1914.

(2) Humus or soluble organic matter by the Grandeau method.

(3) By the author's medium No. 39 (see p. 37).

(4) By Ashby's medium modified with author's soil extract.

(5) By Ashby's medium—the Radicicola present were of the clover group.

Proposed Methods for Investigation.

The methods proposed for carrying out, in the greenhouse, the composting, inoculation of the muck and testing for nodule production were as follows: Four gallon glazed earthenware jars were filled with 10,000 grams of muck containing optimum water conditions. After making the composts this amount was found to overfill somewhat the jars, accordingly the amount placed in each jar was 8,000 grams. In making the composts, the muck was used in about the condition it is piled; that is, containing about 65% moisture. All composts were computed on a ton basis. With the exception of the composts numbers 9, 10, 11, 12, and 13 to which cyanamid was added and 23 and 24 to which guano was added, no nitrogen was used, except the small amount contained in the soil required for inoculation. Inoculation was carried out by using soil containing a well-balanced flora including the nodule organisms of the different groups of valuable agricultural and floral legumes.

The inoculated soil was added in the proportion of 25 lbs. per ton of muck. A stimulant to increase certain groups of soil flora was added in the form of a crude carbohydrate, at the rate of 30 lbs. per ton, except composts Nos. 2B, 3B, 4B, 5B, 6B, 7B and 8B, where 60 lbs. per ton were used.

In measuring inoculation or the efficiency of the compost for nodule production, four of the most important groups of legumes were grown in each compost,—viz. cow peas—soy beans—alfalfa and crimson clover, and a careful study made of the roots. Further, to study the value of the compost as a general soil inoculator, an inoculation in sterilized sand was carried out, using the compost in different amounts on a two million pound acre basis, viz., two lbs., 100 lbs. and 500 lbs. Five different legumes were employed, each representing an individual group, viz., alfalfa, red clover, winter vetch, cow peas and soy beans. To obtain data on the availability of nitrogen, a growth of rye and millet was used. Some chemical data were taken on nitrates which showed marked variations in the different composts. The fluctuations and variations in the flora were studied by plate cultures, using media that were adapted to bring out the more important physiological groups, such as the ammonifiers, the nitrifiers and the azotofiers, including B. radicicola. In making notes on the flora, only radical or marked changes were recorded.

Data for Building Composts.

In order to build neutral composts from various alkaline, acid and neutral products such as the commercial phosphates, unleached hard wood ashes, cyanamid, various carbonates, lime, etc., when added to humus, the following experiments were carried out: various quantities of lime were added to the humus from Alphano, New Jersey, to determine amounts required to neutralize the product. It was found that 4.5 to 7 pounds of calcium oxide will completely neutralize a ton on an air basis; that one pound of CaO will neutralize five pounds of 14% commercial acid phosphate. It was found that cyanamid is very caustic, equalling lime, and that 1 pound of cyanamid will neutralize 5 pounds of commercial 16% acid phosphate. One-tenth pound of CaO will neutralize 1 ton of sheep manure, and 0.11 pound of CaO will neutralize a ton of dried blood; 1 pound of unleached hard wood ashes (chestnut) will neutralize 5 pounds of commercial 16% acid phosphate. It requires about 1 pound of Thomas slag to neutralize 1 pound of commercial 16% acid phosphate.

From the above data, some 40 different composts have been made, running to extremes both on the basic and acid sides.

The Flora Humus from Alphano, N. J.

The studies have been carried out on muck from a composite of the first four feet in digging. It is to be expected that on a muck that has been used for trucking purposes for two or three reasons prior to digging, many of the beneficial soil organisms will be present and active. On the trucking areas and the dikes

at Alphano, clover plants showing an abundant inoculation with the nodule organism were observed. Under such conditions, it would be expected that some B. radicicola of the clover group would be present. This was shown to be true by the clover grown in the noninoculated jars—A, B, and No. 29. (See Plate III). The noninoculated muck showed no sign of the nodule organisms for cow peas, soy beans, alfalfa and vetch.

Plate cultures made with the various media used in these experiments showed that B. radicicola of the clover group was present, varying from 50,000 to 133,000 per gram of moist peat. Various azotobacters were present varying in number from 20,000 to 66,000. The nitrifying organisms were the lowest of all in number, varying from 10,000 to 33,000 per gram of moist peat. The ammonifiers were present from 50,000 to 260,000 per gram. Moulds were very plentiful, varying from 50,000 to 260,000.

A rich and well-balanced soil flora would show all these organisms increased by ten to fifty fold, except the moulds in neutral soils are not very plentiful. In the light soils of lower Delaware, moulds to the number of 100,000 per gram of moist soil, have been taken. From sick soil in North Dakota Fusarium lini, the fungus-causing flax wilt, has been taken to the extent of 45,000 colonies per gram of moist soil.

Table II—Nature of Compost, Amount of Nodule.

11/17/15: Started following composts.		11/20/15: Planted this date: cow peas, soy beans, crimson clover and alfalfa. 1/11/16: All plants removed and nodules and growth observed.		
			Nodules	**Growth**
A		Cow peas	none	good
Humus	2,000 lbs.	Soy beans	"	"
		Crim. clover	many	"
		Alfalfa	few see Comp. No. 29)	"
B		Cow peas	none	good
Humus	2,000 lbs.	Soy beans	"	"
Carbohydrate	30 "	Crim. clover	few	"
		Alfalfa	none	"
C		Cow peas	none	good
Humus	2,000 lbs.	Soy beans	"	"
Inoc. soil	25 "	Crim. clover	many	"
		Alfalfa	some	"

Table II—(Continued).

D		Cow peas	none	good
Humus	2,000 lbs.	Soy beans	some	"
Carbohydrate	30 "	Crim. clover	"	"
Inoc. soil	25 "	Alfalfa	few	"
No. 1A		Cow peas	none	slightly chlorotic
Humus	2,000 lbs.			
Acid Phos. (16%)	50 "	Soy beans	"	slightly chlorotic
$Ca(OH)_2$	20 "			
Organic ash	100 "	Crim. clover	few, scattered	slightly chlorotic
Carbohydrate	30 "			
Inoc. soil	25 "	Alfalfa	good, scattered	slightly chlorotic
No. 1B		Cow peas	none	chlorotic
Humus	2,000 lbs.	Soy beans	"	"
Acid Phos. (16%)	50 "	Crim. clover	very few	"
Organic ash	200 "	Alfalfa	good	"
Carbohydrate	30 "			
Inoc. soil	25 "			

Production, Growth of Legumes and Notes on the Bacterial Flora

1/14/16: Replanted all composts with cow peas, soy beans, crimson clover and alfalfa. 3/30/16: Pulled all plants to study nodules and growth.

Nodules	Growth
well scattered	good
none	"
general	"
general	"
well scattered	good
slight	"
quite general	"
scattered	"
well inoculated	good
quite general	"
abundant	"
quite general	"

Study of flora on media Nos. 22, 23, 39, 43A, 43B, 44A, 44B, 45A, 45B, and 46.

Notes on Bacterial flora

Used last six media above. B. radicicola very few — many fungi—flora low in all media.

Flora fairly good—some Azotobacters; some B. radicicola—no molds.

Very poor flora; few B. radicicola, like A.

Table II—(Continued).

some inoc.	good	Flora good—B. radicicola plentiful. However, nothing like as plentiful as in No. 8A, No. 8B, et al. Much the best check.
general	"	
very good	"	
very good	"	
good	good	Not an abundant flora—some Azotobacters and B. radicicola.
none	"	
few	"	
good	"	
none	fair	Many Azotobacters; not many B. radicicola.
none	"	
few, but large	good	
few, but large	good	

11/17/15: Started following composts:

No. 2A	
Humus	2,000 lbs.
Organic ash	100 "
Carbohydrate	30 "
Inoc. soil	25 "
No. 2B	
Humus	2,000 lbs.
Organic ash	200 "
Carbohydrate	60 "
Inoc. soil	25 "
No. 3A	
Humus	2,000 lbs.
Carb. of potash	50 "
Acid Phos.	50 "
Carbohydrate	30 "
Inoc. soil	25 "

11/20/15: Planted this date: cow peas, soy beans, crimson clover and alfalfa. 1/11/16: All plants removed and nodules and growth observed.

	Nodules	Growth
Cow peas	some	good
Soy beans	"	"
Crim. clover	few	"
Alfalfa	good	"
Cow peas	none	poor
Soy beans	"	"
Crim. clover	"	good
Alfalfa	good	"
Cow peas	none	chlorotic
Soy beans	"	"
Crim. clover	few	"
Alfalfa	fair	"

Table II—(Continued).

No. 3B			Cow peas	(no growth—Carbonate of Potash	
Humus	2,000 lbs.		Soy beans	too strong)"	
Carb. of Potash	100 "		Crimson clover	"	
Acid Phos.	50 "		Alfalfa	"	
Carbohydrate	60 "				
Inoc. soil	25 "				
No. 4A			Cow peas	none	roots not good
Humus	2,000 lbs.		Soy beans	"	roots not good
Carb. of Potash	15 "		Crim. clover	abundant	good
Calcium Carbonate	10 "		Alfalfa	"	good
Acid Phos.	50 "				
Carbohydrate	30 "				
Inoc. soil	25 "				
No. 4B			Cow peas	none	none
Humus	2,000 lbs.		Soy beans	"	none
Carb. of Potash	30 "		Crim. clover	no inoc.	poor
Calcium Carbonate	20 "		Alfalfa	good inoc.	fair
Acid Phos.	50 "				
Carbohydrate	60 "				
Inoc. soil	25 "				

1/14/16: Replanted all composts with cow peas. soy beans, crimson clover and alfalfa. 3/30/16: Pulled all plants to study nodules and growth.

Study of flora on media Nos. 22, 23, 39, 43A, 43B, 44A, 44B, 45A, 45B, and 46.

Nodules	Growth	Notes on Bacterial flora
good	fair	Some few Az. chroococcum and many other Azotobacters. Many B. radicicola
few	"	
few	good	
few	"	
none	fair	An abundant flora—many B. radicicola and Azotobacters.
"	"	
"	poor	
good	"	
none	very poor	Many Azotobacters — few B. radicicola—a fairly good flora.
"	" "	
"	" "	
"	" "	

Table II—(Continued).

none	very poor	Some Azotobacters, but not as many as No. 3A.
"	almost no growth	
"	almost no growth	
"	almost no growth	
fairly good	fair	Many B. radicicola, many Azotobacters—fairly good flora.
" "	"	
very good	good	
splendid	"	
none	plants poor	An abundant flora. Many Azotobacters and many B. radicicola.
"	" "	
some	" "	
none	" "	
11/17/15: Started following composts:		11/20/15: Planted this date: cow peas, soy beans, crimson clover and alfalfa. 1/11/16 All plants removed and nodules and growth observed.

		Nodules	Growth
No. 5A		Cow peas	none	good
Humus	2,000 lbs.	soy beans	some	"
Potassium Carb.	30 "	Crim. clover	abundant	"
Acid Phos.	50 "	Alfalfa	"	"
Carbohydrate	30 "			
Inoc. soil	25 "			
No. 5B		Cow peas	none	poor
Humus	2,000 lbs.			
Potassium Carb.	60 "	Soy beans	"	"
Acid Phos.	50 "			
Carbohydrate	60 "	Crim. clover	quite abundant	quite healthy
Inoc. soil	25 "			
		Alfalfa	inoc. good	quite healthy
No. 6A		Cow peas	none	poor
Humus	2,000 lbs.	Soy beans	"	"

Table II—(Continued).

Sodium Carb.	30 "	Crim. clover	abundant healthy
Acid Phos.	50 "	Alfalfa	" "
Carbohydrate	30 "		
Inoc. soil	25 "		
No. 6B		Cow peas	(No growth—Sodium carbonate
Humus	2,000 lbs.		
Sodium Carb.	60 "	Crim. clover	too strong.)
Acid Phos.	50 "	Alfalfa	
Carbohydrate	60 "		
Inoc. soil	25 "		
No. 7A		Cow peas	quite abundant good
Humus	2,000 lbs.		
Thomas slag	200 "	Soy beans	quite abundant "
Carbohydrate	30 "		
Inoc. soil	25 "	Crim. clover	quite abundant "
		Alfalfa	quite abundant "

1/14/16: Replanted all composts with cow peas, soy beans, crimson clover and alfalfa. 3/30/16: Pulled all plants to study nodules and growth.		Study of flora on media Nos. 22, 23, 39, 43A, 43B, 44A, 44B, 45A, 45B, and 46.
Nodules	**Growth**	**Notes in Bacterial flora**
very slight	fair	Many Azotobacter chroococcum, also other Azotobacters; an abundant flora, exceptionally abundant in B. radicicola.
poor	"	
good inoc.	good	
splendid inoc.	"	
none	fair	An abundant flora — many Azotobacter chroococcum, and other Azotobacters; many B. radicicola. A good flora.
"	"	
slight	good	
good inoc.	"	
none	poor	Many Azotobacters, though not as abundant as in 6B.
"	"	
very slight	"	
" "	"	

Table II—(Continued).

no growth	no growth	Abundant Azotobacter chroococcum. Many urea bacteria—probably B. fluorescens.
" "	" "	
" "	" "	
" "	" "	
splendid	good	Many Azotobacters—B. radicicola not abundant.
very good	"	
small and scattering	"	
small and scattering	"	
11/17/15: Started following composts.		11/20/15: Planted this date: cow peas, soy beans, crimson clover and alfalfa. 1/11/16: All plants removed and nodules and growth observed.

		Nodules	Growth
No. 7B		Cow peas	none	fair
Humus	2,000 lbs.	Soy beans	"	"
Thomas slag	100 "	Crim. clover	quite abundant	"
Carbohydrate	60 "	Alfalfa	quite abundant	"
Inoc. soil	25 "			
No. 8A		Cow peas	abundant	fine
Humus	2,000 "	Sow beans	"	"
Thomas slag	50 "	Crim. clover	"	"
Carbohydrate	30 "	Alfalfa	"	"
Inoc. soil	25 "			
No. 8B		Cow peas	many	fair
Humus	2,000 lbs.	Soy beans	3 on 3 plants	"
Thomas slag	15 "	Crim. clover	many	"
Carbohydrate	60 "	Alfalfa	"	"
Inoc. soil	25 "			
No. 9		Cow peas	none	healthy
Humus	2,000 "	Soy beans	"	"
Cyanamid	10 "	Crim. clover	"	"
Carbohydrate	30 "	Alfalfa	few	"
Inoc. soil	25 "			

Table II—(Continued).

No. 10		Cow peas	none	none
Humus	2,000 "			
Cyanimid	25 "	Soy beans	none	none
Carbohydrate	30 "			
Inoc. soil	25 "	Crim. clover	none	sickly
		Alfalfa	"	"
No. 11		Cow peas	none	none
Humus	2,000 "			
Cyanamid	200 "	Soy beans	none	none
Acid Phos.	200 "			
Carbohydrate	30 "	Crim. Clover	none	none
Inoc. soil	25 "			
		Alfalfa	none	none

1/14/16: Replanted all composts with cow peas, soy beans, crimson clover and alfalfa. 3/30/16: Pulled all plants to study nodules and growth.

Study of flora on media Nos. 22, 23, 39, 43A, 43B, 44A, 44B, 45A, 45B, and 46.

Nodules	Growth	Notes on Bacterial flora
general inoc.	fine	Many Azotobacters and B. radicicola—a good flora.
fair	"	
good	"	
scattered	"	
good inoculation	fine	A very abundant flora—many Azotobacters and many B. radicicola.
" "	"	
scattered	"	
"	"	
good	fine	A very abundant flora—many B. radicicola and Azotobacters —No. 43A is a good medium, and 43B also.
some	"	
scattered	"	
fair	"	
none	weak	An abundant fungus flora has overrun all six media.
"	"	

Table II—Continued.)

none	very weak	Same as No. 9.
"	" "	
"	" "	
"	" "	
no growth	no growth	Most abundant bacterial flora of all. Probably B. fluorescens.
"	" "	
"	" "	
"	" "	

1/11/16: Started following composts.

1/14/16: Planted composts to cow peas, soy beans, alfalfa and crimson clover. 3/30/16: Pulled all plants to study nodules and growth.

		Nodules	Growth
No. 12		Cow pea	none	weak
Humus	2,000 "	Soy beans	"	"
Cyanamid	10 "	Crim. clover	scattered	"
Acid Phos.	50 "	Alfalfa	"	good
Carbohydrate	30 "			
Inoc. soil	25 "			
No. 13		Cow pea	none	weak
Humus	2,000 "	Soy beans	"	"
Cyanamid	20 "	Crim. clover	"	none
Acid Phos.	100 "			
Carbohydrate	30 "	Alfalfa	scattered	good
Inoc. soil	25 "			
No. 14		Cow pea	none	weak
Humus	2,000 lbs.	Soy bean	1 nodule	"
Organic ash	25 "	Crim. clover	scattered large	"
Sodium Carbonate	15 "			
Carbohydrate	30 "	Alfalfa	"	medium
Inoc. soil	25 "			
No. 15		Cow pea	scattered	fair
Humus	2,000 lbs.	Soy bean	slight inoc.	weak
Organic Ash	25 "	Crim. clover	good inoc. large	good
Sod. Carbonate	15 "			
Acid Phos.	50 "	Alfalfa	scattered	"

Table II—(Continued).

Carbohydrate	30 "		large	
Inoc. soil	25 "			
No. 16		Cow pea	none	none
Humus	2,000 lbs.			
Floats	400 "	Soy beans	scattered	weak
Sod. Carbonate	15 "	Crim. clover	none	none
Carbohydrate	30 "			
Inoc. soil	25 "	Alfalfa	"	weak
No. 17		Cow pea	none	weak
Humus	2,000 lbs.	Soy bean	splendid	medium
Floats	400 "	Crim. clover	none	none
Potas. Carbonate	15 "			
Carbohydrate	30 "	Alfalfa	good inoc.	good
Inoc. soil	25 "			

Study of Flora on media Nos. 22, 23, 25, 39, 43A, 43B, 44A, 44B, 45A, 45B, and 46.

Notes on Bacterial flora

Plate C—(C=1/100,000 gram) after two days' incubation—45 colonies. Plate C—Medium 46—after 4 days, 800 to 1,000 colonies—very few Azotobacters, some B. radicicola. Mostly urea bacteria.

Plate C—after two days' incubation—20 colonies. Plate C—medium 46—after four days, 700 to 900 colonies, probably urea bacteria.

Plate C—after two days' incubation—25 colonies. Plate C—medium 46—after four days' incubation—250 colonies, many Azotobacters and B. radicicola.

Plate C—after two days' incubation—30 colonies. Plate C—medium 46—after four days' incubation—about 275 colonies, mostly Azotobacters and B. radicicola.

Plate C—after two days' incubation—30 colonies. Plate C—medium 46—after four days' incubation—200 colonies—some Azotobacters and B. radicicola.

Plate C—after two days' incubation—75 colonies. Plate C—medium 46—after four days' incubation—150 colonies—many Azotobacters and B. radicicola.

TABLE II—(Continued).

1/11/16: Started following composts:

No. 18	
Humus	2,000 lbs.
Floats	100 "
Sod. Carbonate	15 "
Carbohydrate	30 "
Inoc. soil	25 "
No. 19	
Humus	2,000 lbs.
Organic ash	100 "
Carbohydrate	30 "
Inoc. soil	25 "
No. 20	
Humus	2,000 lbs.
Organic ash	50 "
Carbohydrate	30 "
Inoc. soil	25 "
No. 21	
Humus	2,000 lbs.
Organic ash	25 "
Carbohydrate	30 "
Inoc. soil	25 "
No. 22	
Humus	2,000 lbs.
Organic ash	50 "
Calcium carbonate	50 "

1/14/16: Planted composts to cow peas, soy beans, alfalfa and crimson clover. 3/30/16: Pulled all plants to study nodules and growth.

	Nodules	Growth
Cow peas	scattered, small	fair
Soy beans	scattered, small	medium
Crim. clover	none	none
Alfalfa	good	weak
Cow peas	good	good
Soy beans	abundant, large	"
Crim. clover	plentiful big	"
Alfalfa	scattered, big	"
Cow peas	abundant inoc.	very good
Soy beans	very strong	very good
Crim. clover	abundant, large	very good
Alfalfa	very strong	very good
Cow peas	some inoc.	good
Soy beans	medium inoc.	"
Crim. clover	medium inoc.	"
Alfalfa	good inoc.	"
Cow peas	none	none
Soy beans	abundant inoc.	strong
Crim. clover	abundant	very

TABLE II—(Continued.)

Carbohydrate	30 "		inoc.	strong
Inoc. soil	25 "	Alfalfa	good	very strong

Study of Flora on media Nos. 22, 23, 25, 39, 43A, 43B, 44A, 44B, 45A, 45B, and 46.

Notes on Bacterial Flora.

Plate C—after two days' incubation—45 colonies. Plate C—medium 46—after four days' incubation, 200 colonies—Azotobacters and B. radicicola.

Plate C—after two days' incubation has 50 colonies. Plate C—medium 46—after four days' incubation, 100 colonies; large proportion probably Azotobacters—some B. radicicola.

Plate C—after two days' incubation has 20 colonies. Plate C—medium 46—after four days' incubation, 150 colonies—some B. radicicola and Azotobacters.

Plate C—after two days' incubation—30 colonies. Plate C—medium 46—after four days' incubation, 200 colonies—many small Azotobacters and B. radicicola colonies.

Plate C—after two days' incubation—50 colonies. Plate C—medium 46—after four days' incubation, 250 colonies—some Azotobacters and many B. radicicola.

1/11/16 Started following composts:

No. 23	
Humus	2,000 lbs.
Guano	10 "
Calcium carbonate	50 "
Carbohydrate	30 "
Inoc. soil	25 "
No. 24	
Humus	2,000 lbs.
Guano	10 "
Organic ash	50 "

1/14/16: Planted composts to cow peas, soy beans, alfalfa and crimson clover. 3/30/16: Pulled all plants to study nodules and growth.

	Nodules	Growth
Cow peas	few, small	medium
Soy beans	few, large	strong
Crim. clover	abundant, small	good
Alfalfa	few, small	"
Cow peas	small nod.	small
Soy beans	very few	"
Crim. clover	abundant small	"

TABLE II—(Continued.)

Carbohydrate	30 "	Alfalfa	none	none
Inoc. soil	25 "			
No. 25		Cow peas	abundant, very large	very healthy
Humus	2,000 lbs.	Soy beans	good, large	very healthy
Pot Carbonate	10 "	Crim. clover	medium, small	very healthy
Acid Phos.	50 "	Alfalfa	abundant, very large	healthy
Calcium carbonate	100 "			
Carbohydrate	30 "			
Inoc. soil	25 "			
No. 26		Cow peas	few	medium
Humus	2,000 lbs.	Soy beans	abundant, large	healthy
Potassium Carb.	10 "	Crim. clover	plentiful small	"
Thomas slag	25 "	Alfalfa	scattered, small medium size	
Calcium carb.	100 "			
Carbohydrate	30 "			
Inoc. soil	25 "			
No. 27		Cow peas	abundant, large, medium	healthy
Humus	2,000 lbs.	Soy beans	abundant large	very healthy
Calcium carb.	100 "	Crim. clover	none	none
Carbohydrate	30 "	Alfalfa	scattered, small medium size	
Inoc. soil	25 "			
1/11/16: Started following composts.		1/14/16: Planted composts to cow peas, soy beans, alfalfa and crimson clover. 3/30/16: Pulled all plants to study nodules and growth.		
			Nodules	**Growth**
No. 28		Cow peas	abundant, large	very healthy
Humus	2,000 lbs.	Soy beans	abundant large	plants healthy
Organic ash	25 "	Crim. clover	exceedingly abundant	splendid
Thomas slag	25 "	Alfalfa	scattered but large	small
Cal. Carb.	100 "			
Carbohydrate	30 "			
Inoc. soil	25 "			
No. 29		Cow peas	none	healthy
Humus	2,000 lbs.	Soy beans	"	"

TABLE II—(Continued.)

		Crim. clover	good inoc.	"
		Alfalfa	none	"
No. 30		Cow peas	abundant	healthy
Humus	2,000 lbs.		inoc.	
Carbohydrate	30 "	Soy beans	abundant	"
Inoc. soil	25 "		inoc.	"
		Crim. clover	abundant	"
			inoc.	"
		Alfalfa	good inoc.	"

Notes on Bacterial Flora.

Plate C—after two days incubation—60 colonies. Plate C—medium 46—after four days incubation—300 colonies, many Azotobacters, probably A. chroococcum, many B. radicicola.

Plate C—after two days incubation—5 colonies. Plate C—medium 46—after four days incubation—50 colonies some Azotobacters, few B. radicicola.

Plate C—after two days incubation—50 colonies. Plate C, medium 46, after four days incubation—150 colonies, mostly Azotobacters and B. radicicola.

The Flora in the Different Composts.

Remarkable changes were brought about in the muck by the application of various ingredients. The different applications of wood ashes, sodium carbonate and potassium carbonate greatly increased the Azotobacters, especially the species A. chroococcum. (See the dark colonies in plate X).

The influence of basic materials in every compost was to reduce moulds, but in some cases they increased Actinomyces. This observation is in harmony with studies that have been made on agricultural soils, especially those having large amounts of alkaline salts, such as potassium and sodium carbonates. One of the soils from Colorado, high in basic compounds, showed ten million Actinomyces albus per gram. This number is far in excess for this organism from soils which are neutral or acid.

The influence of the carbohydrate was to bring up immediately an abundant Azotobacter flora, the species varying with the amount and nature of the basic materials applied. As stated above, the basic materials containing alkaline compounds greatly favored Azotobacter chroococcum. The inhibiting action on moulds of a properly balanced compost is seen by comparing cultures A and B, Plate VIII in which plate A is from a compost that has been properly balanced by alkaline bases. The influence of lime and other bases was very marked in the great increase of B. radicicola. In some cases the increase was a hundred to a thousand fold or more. The increase of Azotobacters was frequently a thousand fold. The rapid disappearance of moulds was remarkable. They evidently died out, as they failed to come up in the culture media when plating. The most remarkable influence of the bases was upon the nitrifiers, here these minute organisms which carry out such an important work, showed a wonderful increase. The importance of these biological processes and the part played by lime and the alkaline compounds must not be underestimated.

In the composts containing cyanamid and guano, especially the former, marked increases were noticeable in the urea bacteria. The most abundant flora was found in the composts containing cyanamid. Here, a plating from a dilution of 1/1000,000 gram of moist compost was not sufficient to permit of proper development. Over 900 colonies of urea bacteria, probably Bact. fluorescens per 1/1000,000 gram of moist composts were counted or rather estimated in a plate.

Symbroses or Mutualism Probably an Active Factor with Azotobacters and B. radicicola.

Throughout this work there is abundant evidence that there exists a strong mutualism between different species of Azotobacter and B. radicicola. It was observed that in all the media

favorable for growth of Azotobacter, the same was very suitable for B. radicicola; in fact Ashby's medium proposed for Azotobacter, (Jour. of Agr. Science II—1907-8—p. 54), was equally a splendid medium for B. radicicola. It was observed that wherever a colony of B. radicicola started on a plate, that when A. chroococcum or other azotobacters became a part of the colony the rapidity of growth for both was very marked. When Azotobacters are carried in tube cultures they live and make splendid growth when they are associated with B. radicicola. The B. radicicola shows an equal benefit from the mutualism. It is believed that in the older root tubercles or legumes, B. radicicola is rapidly followed up by certain Azotobacters. This appears certain from the many Azotobacters which have found their way into old but apparently sound nodules, as indicated by surface sterilizing and plating. Many years of study of B. radicicola on pure culture and its rapid deterioration and failure, and on the other hand great success when carried in soil has led to the conclusion that symbiosis or rather mutualism is a great factor in preserving and benefiting a soil flora.

It has been inferred by certain producers of commercial inoculants that the organism of each particular legume requires a culture medium slightly different from that of another, and particularly adapted for the organism in question; further that "the germs for one variety of legumes will not work on any other variety of legume." In the light of recent investigations, the present work shows that the organisms for the different groups of the important agricultural legumes may be successfully carried in one and the same compost.

The Influence of Various Compounds on Inoculation.

The influence of the composition of the compost is apparently not so active on the soil flora as it is on the host. This was especially to be noted on the growth of the different legumes. In many instances when the roots of the legumes failed to penetrate deeply into the compost because of excessive acidity or alkalinity, the few roots which were to be found showed an abundant inoculation. On the other hand, in certain composts where the nitrogen availability was too great, although the legumes showed splendid growth and a bountiful root system, little or no inoculation was to be found. It required strong acidity and alkalinity in the compost before a marked falling off in the B. radicicola content could be detected in cultures. On the other hand, a slight excess of sodium and potassium carbonates, either from that applied in organic ash or when applied in the form of chemically pure goods, would show detrimental effect on soy beans and cowpeas. However, red clover and most especially alfalfa were quite tolerant to alkali. Alfalfa was in every case the last to die out

from excessive alkalinity. The influence of an excess of these carbonates was to be seen on the growth of soy bean and cow pea in compost numbers 3A, 3B, 4A, 4B, 5A, 5B, 6A, 6B, 14, 15, 16, 18 and 19. Because of the detrimental effect of these alkalies on soy beans and cow peas in some of these composts no inoculation apparently took place. (See Table II, composts 1A, 1B, 2A, 2B, 3A, 3B, 4A, 4B, 5A, 5B, 6A and 6B). Some of these same composts gave splendid inoculation on clover and alfalfa (See Table II, composts 4A-5A). The size and apparent health of the nodule was very noticeable on clover and alfalfa grown in some of these sodium and potassium carbonate treated pots. The influence of fertilizers carrying nitrogen, such as cyanamid guano, was to inhibit or weaken inoculation. This was plainly seen in composts 12, 13, 23 and 24, and the two former carrying cyanamid nitrogen, and the two latter, nitrogen from a high grade guano.

Statements have been made that the nodule organisms do not live well in an acid soil. In pot C and Pot No. 30, we have added inoculation but no bases; the results were a very good inoculation on all the legumes, soy beans, cow peas, clover and alfalfa and this in a humus that shows a lime requirement of nearly 5000 pounds of CaO per 2,000,000 pound acre. (See plate IV showing photograph of inoculation in pot 30). The growths of the legumes on pots C and 30 were also fairly good, showing that these plants were able to tolerate an acidity in the form of humus, that was nearly three times that of the average acid soil.

The best inoculations were found in those composts which were well balanced in their make-up, such as composts Nos. 8, 25 and 28. Here there is not only an abundant and well distributed inoculation, but also plant growth which shows health and vigor. See plates V and VI for the inoculation in No. 25 and No. 28 and plate II for growth of legumes on these composts.

Inoculation in Sterilized Sand by Use of Composts.

This work was carried out in 7-inch plant pots, sterilizing the sand in the autoclave four hours, at a pressure of fifteen pounds. The composts were used at the rates of 2 pounds, 100 pounds and 500 pounds respectively to a 2,000,000 pound sand acre. (This would be equivalent to about a six inch acre). Five different legumes were employed, representing as many different nodule organism groups, viz., alfalfa, clover, vetch, cow peas and soy beans. This work was done in duplicate. The sand was treated with ground limestone and washings from wood ashes to supply the necessary minerals. The work was duplicated, using two different composts for inoculation. The appearance of the legumes was somewhat better where 100 pounds and

500 pounds respectively of the composts were used, but upon examination, it was found that good inoculation had taken place in all the pots, and among all the legumes. (See Plate VII). This work readily indicates that the organism for each and all of the important groups of agricultural legumes may be carried in one compost. An observation which was of particular interest in this work was the immense amount of root groth in the sand cultures as compared with the top growth on the legumes. The same relationship must take place in the growth of legumes on weak sandy soils. The following shows dry weights in grams, of tops and roots from the series inoculated with 100 pounds of compost per acre.

Dry Weights of Tops and Roots of Legumes Grown in Sand Cultures.

	Wt. of Tops	Wt. of Roots.
Alfalfa	5.1 grams	12 grams
Clover	4. "	12 "
Vetch	4.5 "	11 "
Cow Peas	7.2 "	10 "
Soy Beans	6. "	9 "

The splendid inoculation produced in these sand cultures would indicate that such humus as was used in these experiments, could readily be inoculated and composted so as to carry all the important organisms for the inoculation of the different groups of important agricultural legumes.

The Influence of the Basic Compounds on the Availability of Humus Nitrogen.

The importance of basic compounds in making available the nitrogen of humus has long been known. Certain of the elements, such as calcium, magnesium, iron, manganese and aluminum form insoluble humates in the soils, while others such as sodium and potassium especially the carbonates of these and the compound ammonia, have the property of making humates soluble. Humus or probably more properly speaking, humic acid has stronger affinity for sodium, potassium, iron, aluminum, and phosphorus than it has for calcium and magnesium. This is very evident when the Grandeau method for humus is applied, in which the calcium and magnesium are almost entirely taken out by the preliminary treatment with weak hydrochloric acid, while the other basic materials are not separated from the humus. This fact is plainly seen when the ash content of humus as reported by Snyder (1) (Hilgard, "Soils," p. 134, 1906), and given herewith for reference is observed.

Ash of Humus from Minnesota Prairie Soils.

Isoluble matter	61.97
Potash (K_2O)	7.50
Soda (Na_2O)	8.13
Lime (CaO)	0.09
Magnesia (MgO)	0.36
Peroxide of Iron (Fe_2O_3)	3.12
Alumina (Al_2O_3)	3.48
Phosphoric Acid (P_2O_5)	12.37
Sulfuric Acid (SO_3)	.98
Carbonic Acid (CO_2)	1.64

The cultural tests with rye and millet were used only as indicators to show whether small or large amounts of the humus nitrogen were being made available for the plants. The following table shows the crop response from rye both green and dry, which was harvested from the different composts after a growing period of eight weeks. (See Plates XI, XII and XIII).

Table III. Showing Green and Dry Weights of Rye Grown Eight Weeks.

Compost No.	Green Wt. in Grams	Dry Wt. in Grams.
A check	63	11
B	88	16.5
C	56	11
D	117	25
1A	252	45
1B	312	45
2A	187	34.5
2B	257	38.5
3A	167	34
3B	78	10.5
4A	95	21.0
4B	220	40
5A	141	31
5B	169	32
6A	160	34
6B	130	23
7A	125	26.5
7B	125	24
8A	Pot removed before data were taken.	
8B	173	33.5
9	342	66
10	313	60.5
11	0	0
12	303	47
13	57	18

TABLE III. (Continued.)

14	115	19
15	107	25.5
16	127	23
17	89	21
18	146	29
19	210	40
20	149	32
21	146	30
22	152	31
23	383	54
24	281	49
Compost No.	Green Wt. in Grams.	Dry Wt. in Grams
25	Pot removed before data were taken.	
26	139	28
27	73	14.5
28	100	22.5
29 check	50	11.5
30 check	75	16.5

From Table III, it is very apparent that the addition of certain basic materials has strong influence on the nitrogen assimilation. Check composts A and No. 29 show the response from humus not reinforced or inoculated with soil organisms; these gave a response to rye of 11 and 11.5 grams of dry material (See Plates XI and XIII.)

Check C shows that inoculation alone did not help any, giving a dry weight of only 11 grams; however, when a stimulant or bacterial food such as a crude carbohydrate is added, the pot, without inoculation, is increased by 5.5 grams or 50 per cent., as seen in Check B. When such crude carbohydrate and inoculation are added, the increase is 14 grams or about 122 per cent. Composts numbers 1A, 1B, 2A, and 2B show the importance of organic ash, both with and without adition of acid phosphate. The two former have additions of acid phosphate, and show nearly 50 per cent. increase above the two latter, which have no additional phosphorus. The difference between Check D, and composts 2A and 2B respectively, shows the influence of organic ash, which is an increase of 9.5 grams and 13.5 grams, or when placed on a per cent. basis, is 34 per cent. and 54 per cent.; the latter shows that when it comes to rye response that 200 pounds of organic ash per ton of humus is superior to 100 pounds. However, 50 pounds of acid phosphate, when added to the 200 pounds of organic ash per ton of compost, show a further increase, viz., the difference between 45 grams and 38.5 grams, or 6.5 grams, which is an increase of nearly 17 per cent.

The detrimental effects of an excess of sodium of potassium

carbonates are to be observed in various composts from 3A to 6B and 14 to 18 respectively, in which certain pots made very poor growth, especially 3B, in which 100 pounds of potassium carbonate and 50 pounds of commercial 16 per cent. acid phosphate were used. Here, the dry weight was only 10.5 grams, which was 14.5 grams less than check D. Detrimental effects with 15 pounds or more sodium and potassium carbonates were observed unless the compost was properly balanced with acid rye, as seen by comparing compost No. 19, containing ashes which sodium or potassium carbonate resulted in decreased yields of rye, as seen by comparing compost No. 19, containing ashes which gave a dry weight of 40 grams, with composts Nos. 14 to 18 respectively, in which ashes were reinforced with sodium or potassium carbonates; here, the weights were 19, 25.5, 23, 21 and 29 grams respectively.

Calcium carbonate does not equal the response of wood ashes; this is seen by comparing compost No. 19, containing 100 pounds of ashes per ton of humus and producing a dry weight of rye of 40 grams, with compost No. 27 containing an equal amount of calcium carbonate per ton of humus, which gave a rye response of 14.5 grams.

It is very difficult to make a comparison in humus pot cultures of the value of humus nitrogen with that of cyanamid and guano nitrogen, from the fact that the humus must be properly balanced before proper crop response can be expected. Such comparisons were attempted with cyanamid in pots Nos. 9, 10, 11, 12 and 13, in which pots No. 9 and No. 12 were supposedly well balanced composts. However, 10 pounds of cyanamid in a ton of humus, with no acid phosphate added, gave a higher rye response than did 10 pounds of cyanamid and fifty pounds of acid phosphate. It may be that where the acid phosphate was added, an inhibiting effects from this combination took place, although such was not the case when acid phosphate was used with ashes. The dry weights were respectively 66 grams and 47 grams. When cyanamid at the rate of 25 pounds per ton of humus was added, the crop response on rye was 60.5 grams dry weight as compared with 47 grams when 10 pounds of cyanamid and 50 pounds of acid phosphate were added. Ten pounds of cyanamid alone gave a higher rye response (66 grams per dry weight) than did ten pounds of guano when the humus and the latter were balanced with 50 pounds of calcium carbonate or 50 pounds of ashes. (Compare pot 9 with pots 23 and 24).

The highest responses given to rye by the best humus composts to which no nitrogen was added, were found in composts 1A, 1B and No. 19, in which the dry weights were respectively 45, 45 and 40 grams. This is an increase over the untreated or uncomposted humus, using check A (11 grams dry weight) or

34, 34 and 29 grams respectively; in the two former the increases are over 300 per cent. Comparing this with the responses from the properly composted guano, which gave an increase over check A of 38 and 43 grams respectively, the response from the humus nitrogen is a close competitor. The chief object, however, of adding cyanamid and guano nitrogen was not to obtain a comparison of crop response from these different sources of nitrogen, but to learn whether greater crop response could be brought about by such addition, and further whether cyanamid and guano were suitable sources for such reinforcement. Rye, in some cases, as noted above, gave slight additional increase from reinforcement with cyanamid and guano, while millet on the other hand gave greater response from twelve different composts, not reinforced with nitrogen, than from those pots receiving additional nitrogen from cyanamid and guano. The response from the cyanamid nitrogen in pot 9, viz., 66 grams dry weight, compares favorably with that from guano nitrogen in pot 23, which gave 54 grams dry weight. Here equal weights are being used; that is, 10 pounds of each in a ton, and the former is listed to contain nearly twice the amount of nitrogen as the latter. The guano was represented to be "genuine Peruvian Guano" having the following analysis

Nitrogen	10.69%
Equivalent to ammonia	13.00%
Available phosphoric acid	10.00%
Total phosphoric acid	11.00%
Actual potash	2.00%

Crop Response from Millet.

A study of the crop response from millet shows even more favorable results from the composts. None of the pots reinforced with cyanamid nitrogen or guano equalled the composts Nos. 1A, 1B, 7B and 22. In fact there were 12 different composts which gave a higher crop production than did those reinforced with cyanamid and guano.

With the exception of compost No. 22, compost 1B was again the most productive, being closely followed by No. 7B and No. 1A. The dry weight with millet from these leading pots was over five times that from check A, while with rye it was only four times that of the check. No attempt will be made to interpret the response from the different composts. It is sufficient to indicate the compounds which appear to be very active in bringing about such response. Carbohydrates, apparently have great influence, as there is a difference between raw humus in check A and that of humus and the crude carbohydrate in check B of 38 grams which is a response of nearly 176%. The addition of ashes to check D, as seen in pot 2A, gives 94 grams dry weight

or an increase from 65 to 94 grams, that is 29 grams, which is equal to 44.6% increase.

If compost 1B is compared with check A, it is evident that the addition of acid phosphate, ashes, the crude carbohydrate and inoculation changes the response from 22 grams, dry weight to 116 grams or an increase of 472.7%.

Inoculation as shown in crop response in rye and millet has been the weakest factor at work, the increase from check A to check C amounting to three grams, that is the difference between 22 and 25 grams; that is an increase of only 13.6%. The increase produced by inoculation in the presence of a crude carbohydrate as seen in the increase from check B to check D is only 8.3%. Ashes and ground limestone more than doubled the crop as seen by comparing check 30 with pot 22 in which the former produced 55 grams and the latter 121 grams. The detrimental influence of an excess of potassium carbonate is seen in compost 3B, in which 100 pounds were added per ton of humus. In compost 6B, 60 pounds of sodium carbonate show a decidedly injurious effect. Table IV shows the green and dry weights of millet produced in eight weeks of growth on the different composts.

Table IV Showing Green and Dry Weights of Millet Grown Eight Weeks.

Compost No.	Green Wt. in Grams.	Dry Wt. in Grams.
A check	105	22
B "	282	60
C "	125	25
D "	297.5	65
1A	377	113
1B	387.5	116
2A	325.5	94
2B	415	97
3A	310	75
3B	97.5	20
4A	192.5	34
4B	382	96.5
5A	387.5	106
5B	410	109
6A	253	63
6B	57.5	11
7A	248	52
7B	397	114
Compost No.	Green Wt. in Grams.	Dry Wt. in Grams.
8A	Pot Removed	Pot Removed
8B	310	65
9	175.5	42

TABLE IV. (Continued.)

10	130	35
11	0	0
12	177	36
13	262.5	60
14	340	90
15	382.5	108
16	270	54
17	357.5	69
18	240	58
19	328	92
20	355	86
21	302.5	63
22	352	121
23	100	19
24	382	76
25	Pot Removed	Pot Removed
26	340	75
27	165	29
28	355.5	85
29	114	22
30	257.5	55

Crop Responsive in Relation to Nitrification and Water Soluble Humus.

It was thought that probably some light would be thrown upon the crop response by a study of nitrification. Accordingly, after harvesting the rye, the composts were carefully worked over, that is, thoroughly mixed and moistened down; they were then kept at optimum conditions for two weeks when samples were removed for a study of nitrification. Twenty gram samples of the air dried composts were moistened with 150 cc of distilled water. After shaking for fifteen minutes, 100 cc of the water extract was filtered off and evaporated for nitrate determination. In some instances the color of the water extract was a very dark brown, showing that the treatment with the alkali carbonates was making the humus soluble. The following table shows the color of the water extract, the reaction to litmus paper, and the amount of nitrate present in 20 grams of the air dry compost.

TABLE V.

Showing Color of Water Extrac, Reaction to Litmus Paper, and Amount of Nitrates Found in Each Compost.

No. of Compost	Color of Water Extract	Reaction to Litmus.	Milligrams of Nitrate in 20 grams of Compost.
A	light straw	acid	.0100

Table V—(Continued).

No. of Compost	Color of Water Extract	Reaction to Litmus.	Milligrams of Nitrate in 20 grams of compost.
25	compost removed before data were taken		
B	light straw	acid	.0200
C	light straw	acid	.0500
D	light straw	acid	.0150
1A	almost clear	alkaline	.0400
1B	darker than A	alkaline	.0300
2A	quite yellow	alkaline	.0350
2B	strong cider yellow	alkaline	.0950
3A	yellowish brown	alkaline	2.5000
3B	very dark brown	alkaline	.0100
4A	lighter than A	almost neutral	.0200
4B	darker than A	alkaline	.0150
5A	darker than A	alkaline	.0400
5B	quite yellow	alkaline	.0250
6A	stronger than 5B	alkaline	.6000
6B	very dark brown	alkaline	.0200
7A	same as A	alkaline	.0250
7B	same as A	alkaline	
8A	compost removed before data were taken		
8B	same as A	alkaline	.0250
9	clearer than A	alkaline	3.6875
10	very clear	alkaline	10.6500
11	darker than A	alkaline	.0800
12	clearer than A	acid	5.6250
13	clearer than A	acid	8.5250
14	Red cherry brown	alkaline	.0650
15	same as A	alkaline	.0100
16	very dark brown	alkaline	.0350
17	cider brown	alkaline	.0200
18	dark brown	alkaline	.0250
19	quite yellow	alkaline	.0150
20	same as A	alkaline	.0100
21	lighter than A	alkaline	.0200
22	same as A	alkaline	.0150
23	lighter than A	alkaline	.0050
24	little darker than A	alkaline	.1050
26	little darker than A	alkaline	.0100
27	same as A	alkaline	.0250
28	same as A	alkaline	.0100
29	same as A	acid	.0300
30	little darker than A	acid	.0250

From a study of Table V it is readily noticeable that composts showing almost no nitrate nitrogen gave splendid crop response with both rye and millet. It is difficult to know just how to interpret this. It is quite probable that other forms of nitrogen than nitrate cause ready crop response; and it may be possible that this form of nitrogen is not even the ammoniacal form.

The small amount of nitrate nitrogen in compost No. 11 would indicate that 200 lbs. of cyanamid per ton of humus is sufficient to stop entirely nitrification. On the other hand 25 lbs. of cyanamid per ton of humus shows strong nitrification. The composts containing guano showed less nitrate nitrogen than the check pots. It is hard to interpret this fact unless a denitrifying flora is at work.

Some Modifications of Media Used in This Work.

For general plating of B. radicicola and Azotobacters, Ashby's medium has been used. (Jour. Agr. Sci. Vol. II, p. 54 1907-'08). It is prepared as follows:

Mannit	10.0 grams
Mono-potassium phosphate	0.2 "
Magnesium sulphate	0.2 "
Sodium chloride	0.2 "
Calcium sulphate	0.1 "
Calcium carbonate	5.0 "
Agar	12.0 "
Pure water	1000.0 cc

To favor a better growth of Azotobacter, Nitrosococcus and Nitrobacter, the following soil extract has been substituted in place of the water above. Take 500 grams of rich garden soil and add 2,000 cc of water to which one gram each of ammonia tartrate and sodium citrate have been added. After vigorously shaking, the soil is allowed to settle; upon standing 24 hours the clear supernatant liquid is siphoned off. 1,000 cc of this soil extract is substituted for the water in Ashby's medium. (This medium is the senior author's medium No. 46).

To favor the nitrifiers (Nitrosococcus and Nitrobacter) one gram of ammonium sulphate per liter of medium was added to Ashby's medium with the above soil extract.

The following medium known as the author's medium No. 39 is of especial value in bringing out nitrifiers so they may be seen as brown colonies on the plates. In plating soils on this medium, large plates of 110 mm or larger in diameter and only 10 cc of medium are used, so that a thin layer of medium is formed. One-

ten thousandth or one-one hundred thousandth gram of soil is used for each plate.

Monopotassium phosphate	(KH_2PO_4)	4.0 Grams
Ferric sulphate		0.2 "
Wood ashes (hard)		12.0 "
Mannit		10.0 "
Agar		15.0 "
Soil Extract (Manns', as noted above)		1000.0 cc

After tubing above (10 cc to a tube) add to each tube one gram of the following insoluble mixture, the ingredients of which have been passed through a sieve of 120 mesh to the inch.

Calcium limestone (ground rock)	100 Grams
Kaolin	20 "
Gypsum	10 "
Dolomite	5 "
Rock phosphate (floats)	5 "

After liquifying the medium and just prior to plating, add to each tube 1 cc of a sterile ammonium sulphate solution made as follows—one gram of ammonium sulphate in 100 cc of water. The object of adding the sterile ammonium sulphate just prior to plating is to prevent loss of ammonia which would take place if the ammonium sulphate was added with the other ingredients which are basic.

When adding the soil dilution in the process of plating, thoroughly shake just before pouring so that the above insoluble minerals will be evenly distributed throughout the plate. It will form a gray mass or background on which the brown nitrifiers are very visible. For class work a qualitative test may be made around each nitrifying colony showing the plentiful formation of nitrates by a heavy blue coloration with the use of diphenylamine. This medium has been successfully used for several years by the senior author in class work.

Summary.

1. Muck humus of the quality in these experiments becomes, when properly balanced and reinforced, a very favorable medium for carrying a beneficial soil flora.

2. The flora or virgin muck humus was found low in many of the beneficial bacteria. Different legume nodule organisms were absent, though the clover group was present to a limited amount. The alfalfa, vetchpea, bean, cow pea and soy bean groups were absent (see plate III).

3. Muck humus when properly reinforced, inoculated and composted will carry the several groups of the different legume organisms in one and the same compost, producing a strong inoculation on the different legumes.

4. Inoculation of the compost may be satisfactorily brought

about by using soil which has been proved to give strong inoculation to each of the groups of legumes. Azotobacter chroococcum may be readily introduced by using western soil; soils from Colorado and North Dakota were used in these experiments. Other species of Azotobacter are common in eastern soils. Nitrifiers are common in all good soils.

5. Muck humus properly reinforced, inoculated and composted gave strong inoculation to five groups of legumes, when the latter were grown in sterilized sand cultures, using the compost at the rate of two pounds per a 2,000,000 pound acre. A somewhat stronger inoculation and growth were produced by using the compost at the rate of 100 and 500 pounds respectively to a two million pound acre in sand cultures (see plate VII).

6. Crude carbohydrates and basic compounds such as organic ash and Thomas slag proved very efficient in bringing up an active legume flora, and likewise a strong nitrogen fixing and nitrifying flora.

7. Organic ash proved the most active mineral application for use in the compost as indicated by crop response.

8. By properly reinforcing the composts with certain basic compounds, all the nitrogen required for crop response was made available as indicated by the growth of millet; the crop response from additional nitrogen from cyanamid and guano did not equal that from certain of the composts.

9. This work shows that the nodule organism may live well in a muck humus having a lime requirement of 5,000 pounds of CaO to two million pound acre; also that in this same acidity four different legumes, viz. alfalfa, red clover, soy bean and cow pea, made good growth and took good inoculation without addition of any bases (see plate IV).

10. Muck humus as herewith reinforced and composted gave splendid crop response to rye and millet without the addition of nitrogen, indicating it to be a product of good fertilizing value.

Descriptions of Illustrations.

Plate I—Showing four different legumes, viz alfalfa, clover, cow pea, and soy beans, growing in the different composts to test same for inoculation.

Plate II—Same as plate I, showing four different legumes, viz., alfalfa, clover, cow pea, and soy beans growing in different composts to test same for inoculation.

Plate III—Showing the amount of inoculation carried in the natural humus as dug from the trucking fields. The legumes were one month old when removed for photographing; (1) soy bean, (2) alfalfa, (3) crimson clover, (4) cow pea. The clover group is the only form of B. radicicola present.

Plate IV—Showing amount of inoculation taking place in one month's growth on soy bean, alfalfa, clover and cow pea, in natural humus to which inoculation but no minerals or bases have been added. A stimulant in the way of a crude molasses has been added. The inoculation is nearly equal to that shown in plates V and VI, to which bases have been added. Compare plate IV with plate III.

Plate V—Showing the amount of inoculation in compost No. 25, in which bases have been employed. The soy beans, alfalfa, clover and cow peas have taken a strong inoculation in one month. Compare with plate III.

Plate VI—Showing the amount of inoculation in compost No. 28 in which bases have been employed—all the legumes have taken a strong inoculation in one month.

Plate VII—Showing growth of five legumes in sand culture, viz., alfalfa, crimson clover, vetch, cow peas and soy beans, representing as many different groups as B. radicicola. The amount of compost used was 2 lbs., 100 lbs. and 500 lbs. respectively. All showing strong inoculation indicating that in one compost all the groups may be successfully carried.

Plate III—Showing type of flora in natural humus (A) before composting and after composting (B). The moulds and Actinonyces disappear and Azotobacters, B. radicicola, and nitrifiers become abundant. Culture A is from 1/10,000 gram of muck, and culture B is from 1/100,000 gram of muck.

Plate IX—Showing the bacterial flora from one-one hundred thousandths of a gram of soil, grown on Ashby's medium, comparing composts No. 20, 21, 22, 23 and 24, with the natural humus No. 29. A large increase in Azotobacters and B. radicicola has taken place.

Plate X—Showing the bacterial flora from one one-hundred thousandths of a gram of soil, grown on the author's medium, No. 46, adapted for Azotobacters, Here Az. chroococcum is shown plentiful in composts No. 1, 1-B, 6 and 6-B.

Plate XI—Showing growths of rye on the different composts. The influence of the bases is readily seen in composts 1-A and 1-B.

Plate XII—Continuation of work shown in plate XI—rye growing in different composts.

Plate XIII—Continuation of work shown in plates XI and XII—Rye growing in different composts.

Plate XIV—Showing color of water extracts from different composts. Some were very dark brown. See Table V.

C
Inoc. 25
D
Carbohyd 30
Inoc 25
1A
Acid Phos 50
CaCO3 20
Org. Ash 100
Carbohyd 30
Inoc. 25
1B
Acid Phos 50
Org. Ash 200
Carbohyd 30
Inoc 25
2A
Org. Ash 100
Carbohyd 30
Inoc. 25
2B
Org. Ash 200
Carbohyd. 60
Inoc. 25
C
Inoc 25
D
Carbohyd 30
Inoc 25
3A
K2CO3 50
Acid Phos 50
Carbohyd 30
Inoc. 25
3B
K2CO3 100
Acid Phos 50
Carbohyd 30
Inoc. 25
4A
K2CO3 15
CaCO3 10
Acid Phos 50
Carbohyd 30
Inoc 25
4B
K2CO3 30
CaCO3 20
Acid Phos 50
Carbohyd 60
Inoc. 25
C
Inoc 25
D
Carbohyd 30
Inoc 25
5A
K2CO3 30
Acid Phos 50
Carbohyd 30
Inoc. 25
5B
K2CO3 60
Acid Phos 50
Carbohyd 60
Inoc 25
6A
Na2CO3 30
Acid Phos 50
Carbohyd 30
Inoc 25
6B
Na2CO3 60
Acid Phos 50
Carbohyd 60
Inoc. 25
C
Inoc 25
D
Carbohyd 30
Inoc 25
7A
Thomas Slag 100
Carbohyd. 30
Inoc. 25
7B
Thomas Slag 100
Carbohyd 60
Inoc. 25
8A
Thomas Slag 50
Carbohyd. 30
Inoc. 25
8B
Thomas Slag 15
Carbohyd. 60
Inoc. 25

PLATE I.

A
Check
B
Carbohydrate
30
9
Cyanamid 10
Carbohyd 30
Inoc. 25
10
Cyanamid 25
Carbohyd 30
Inoc. 25
11
Cyanamid 200
Acid Phos. 200
Carbohyd 30
Inoc. 25
12
Cyanamid 10
Acid Phos. 30
Carbohyd. 30
Inoc. 25
13
Cyanamid 20
Acid Phos. 100
Carbohyd 30
Inoc. 25
14
Org. Ash 25
Na2CO3 15
Carbohyd 30
Inoc. 25
15
Org. Ash 25
Na2CO3 15
Acid Phos 30
Inoc. 25
16
Floats 400
Na2CO3 15
Carbohyd 30
Inoc. 25
17
Floats 400
Na2CO3 15
Carbohyd. 30
Inoc. 25
18
Floats 100
Na2CO3 15
Carbohyd. 30
Inoc. 25
19
Org. Ash 100
Carbohyd. 30
Inoc. 25
20
Org. Ash 50
Carbohyd. 30
Inoc. 25
21
Org. Ash 25
Carbohyd. 30
Inoc. 25
22
Org. Ash 50
CaCO3 50
Carbohyd. 30
Inoc. 25
23
Guano 10
CaCO3 50
Carbohyd. 30
Inoc. 25
24
Guano 10
Org. Ash 50
Carbohyd. 30
Inoc. 25
25
K2CO3 10
Acid Phos. 50
CaCO3 100
Carbohyd. 30
Inoc. 25
26
K2CO3 10
Thomas Slag 25
CaCO3 100
Carbohyd. 30
Inoc. 25
27
CaCO3 100
Carbohyd. 30
Inoc. 25
28
Org. Ash 25
Thomas Slag 25
CaCO3 100
Carbohyd 30
Inoc 25
29
Check
30
Carbohyd. 30
Inoc. 25

PLATE II.

PLATE III.

PLATE IV.

PLATE V.

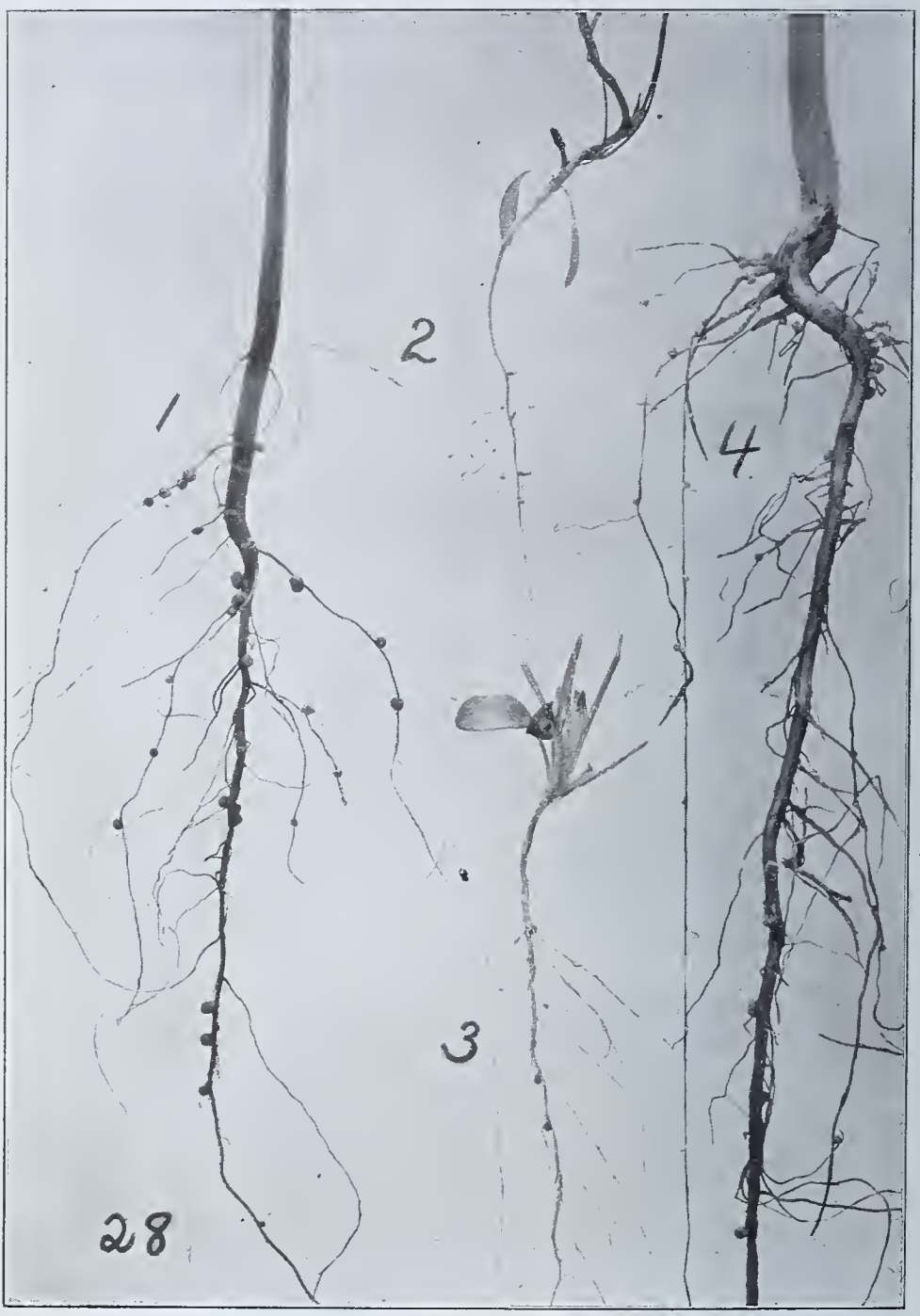
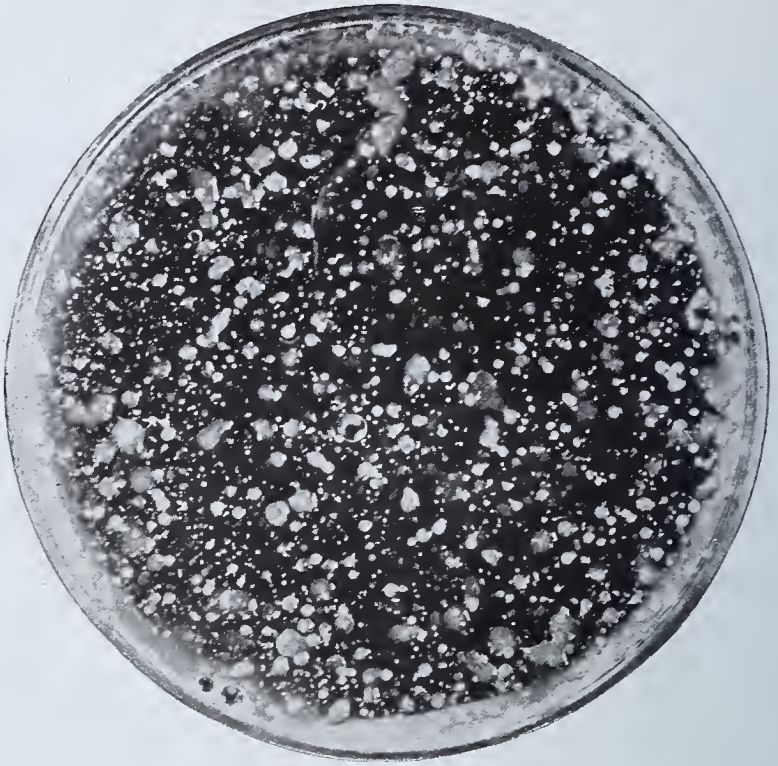


PLATE VI.

Compost
2 lbs
per acre
Compost
100 lbs
per acre
Compost
50 lbs

PLATE VII.



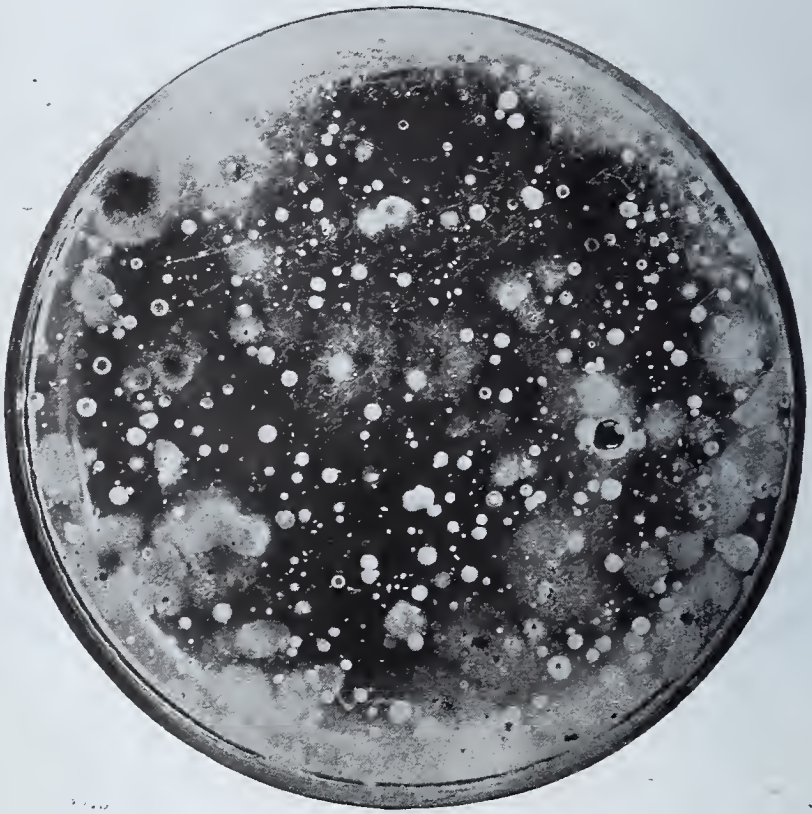


PLATE VIII.

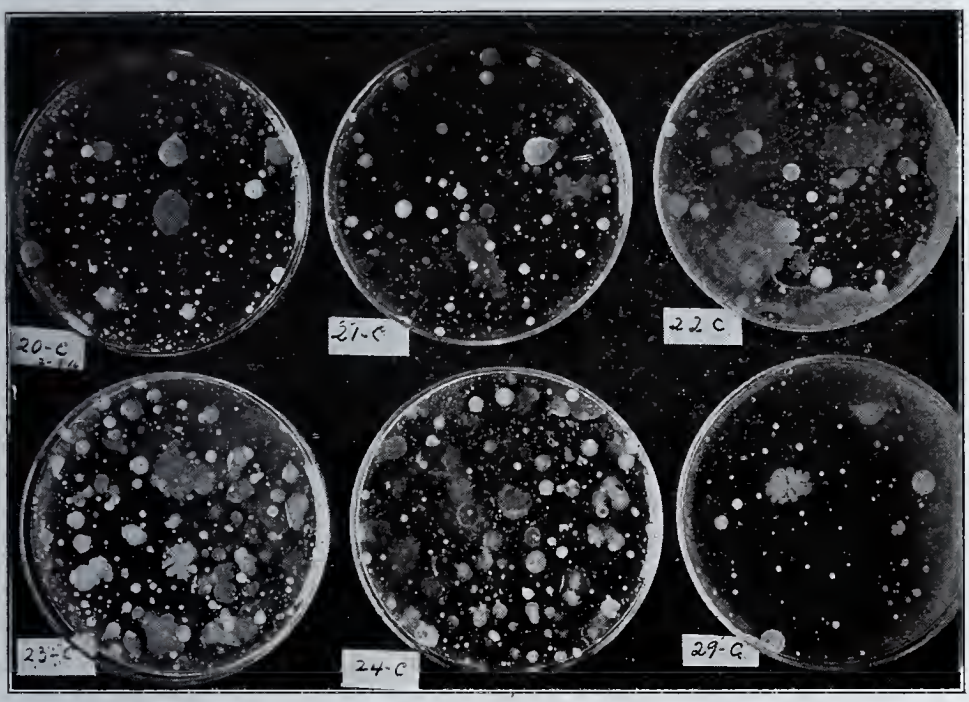


PLATE IX.

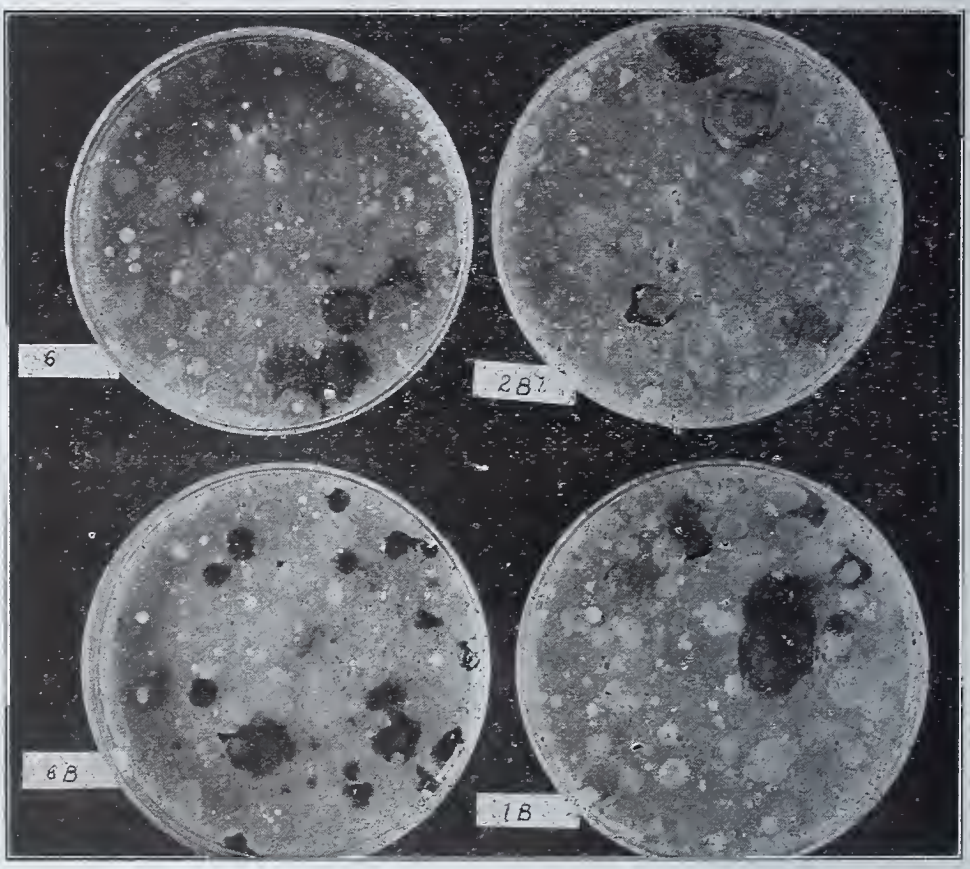


PLATE X.

A
Check
B
Carbohyd 30
C
Inoc 25
D
Carbohyd 30
Inoc 25
1A
Acid Phos 50
Ca(OH)2 20
Org. Ash 100
Carbohyd 50
Inoc 25
1B
Acid Phos 50
Org. Ash 200
Carbohyd 30
Inoc 25
2A
Org Ash 100
Carbohyd 30
Inoc 25
2B
Org Ash 200
Carbohyd 60
Inoc 25
3A
K2CO3 30
Acid Phos 50
Carbohyd 30
Inoc 25
3B
K2CO3 100
Acid Phos 50
Carbohyd 30
Inoc 25
4A
K2CO3 15
CaCO3 10
Acid Phos 50
Carbohyd 30
Inoc 25
4B
K2CO3 30
CaCO3 20
Acid Phos 50
Carbohyd 60
Inoc 25
5A
K2CO3 30
Acid Phos 50
Carbohyd 30
Inoc 25
5B
K2CO3 60
Acid Phos 50
Carbohyd 60
Inoc 25
6A
Na2CO3 30
Acid Phos 50
Carbohyd 30
Inoc 25
6B
Na2CO3 60
Acid Phos 50
Carbohyd 60
Inoc 25
7A
Carbohyd 30
Inoc 25

PLATE XI.

A
Check
9
Cyanamid 10
Carbohyd 50
Inoc 25
10
Cyanamid 25
Carbohyd 50
Inoc 25
11
Cyanamid 200
Acid Phos. 200
Carbohyd 50
Inoc 25
12
Cyanamid 10
Acid Phos 50
Carbohyd 50
Inoc 25
13
Cyanamid 20
Acid Phos. 100
Carbohyd 30
Inoc 25
7b
Thomas Slag 60
Carbohyd 60
Inoc 25
8B
Thomas Slag 15
Carbohyd 60
Inoc 25
14
Org Ash 25
Na2CO3 15
Carbohyd 50
Inoc 25
15
Org Ash 25
Na2CO3 15
Acid Phos 50
Inoc 25
16
Floats 100
Na2CO3 15
Carbohyd 50
Inoc 25
17
Floats 100
K2CO3 15
Carbohyd 50
Inoc 25
18
Floats 100
Na2CO3 15
Carbohyd 50
Inoc 25
19
Org Ash 100
Carbohyd 30
Inoc 25
20
Org Ash 50
Carbohyd 30
Inoc 25
21
Org Ash 25
Carbohyd 30
Inoc 25
22
Org Ash 50
CaCO3 20
Carbohyd 30
Inoc 25
23
Guano 10
CaCO3 50
Carbohyd 30
Inoc 25

PLATE XII.

PLATE XIII.

PLATE XIV.

USE OF PEAT IN PRODUCER GAS PLANTS.

At a meeting of the Liverpool section of the Society of Chemical Industry held in the Chemistry Theatre of Liverpool University on Friday, Nov. 3, Mr. John Gray, chairman of the section, presiding, a paper was read by Professor E. C. C. Baly on "The Use of Peat in Producer-Gas Plants."

The essential difficulty in the utilization of peat was to be found, Professor Baly said, in its enormous bulk in relation to its thermal efficiency. Add to that the very high water content of freshly cut peat and the trouble and peculiar difficulties involved in its effective drying, and the failures which had been reported were such as any modern man of science would fully have expected.

He had the opportunity a few weeks ago of inspecting a works in Ireland the motive power for which was obtained from gas engines supplied with gas obtained from producers fed with peat. Although these works were small, the economy was so obvious that he felt it worth while to find out what had been done in other countries, and no doubt whatever was left in his mind that the utilization of peat in gas-producer plants had been carried out, and was being carried out, so economically as to make him feel that it was necessary entirely to alter our ideas of the value of our peat bogs.

The plant at Messrs. Hamilton, Robb's works, Portadown, to which he alluded, had been in use for five years. It was as simple as possible in design, and no effort was made to recover any of the by-products. It was a suction plant, and the composition of the gas usually obtained approximated: CO 19 per cent, H_2 18 per cent, CH_4 1.6 per cent, CO_2 7 per cent, N_2 54 per cent, with a calorific value of, say, 140 B. t. u. per cubic foot. In the case of the Portadown works there were two producers, each with a capacity of 200 H. P. and there were two Crossley gas engines of 120 H. P. and one of 150 H. P. The gas drawn from the producers before being used must be freed from tar and dust. Nothing was done with the tar. The peat was obtained from a bog 12 miles away where it was air dried. For the working cost of the plant he was indebted to a paper by G. Fletcher, (Jour. Dept. Agri., Ireland vol. 16, 1915, p. 33). The figures were as follows:

Cost of running per week on coal.

8.5	tons* anthracite @$8.05	$ 68.48
19	tons* steam coal @ $3.91	74.29
		$142.77

*The tons used in this article are gross tons (2240 lbs.).

Cost of running per week on peat.

50 tons* of peat @ $1.38	$ 69.00
Extra labor	3.45
Saving	70.32
	$142.77

These figures were, however, obtained in 1912. In view of the fact that all the valuable by-products were not utilized it must be confessed that the above return of cost was eminently satisfactory. The by-products from peat producer gas were peculiarly valuable, especially when Irish peat was used, owing to the relatively high percentage of nitrogen in the peat.

According to Bone's article on "Fuel" in Thrope's Dictionary of Applied Chemistry, it was possible in Mond plant with a ton of coal containing 1.2 to 1.6 per cent of nitrogen to obtain 90 pounds of $(NH_4)_2 SO_4$ and 150,000 cubic feet of gas, with a calorific value of 150 B. t. u. per cubic foot. The use of the steam in the Mond gas plant at once opened the door to the use of peat, which contained considerable quantities of moisture, for the moisture increased the ease with which the nitrogen was recovered as ammonia. The following figures were instructive as to the results which had been obtained from peat in producers, by the Power Gas Corporation, of Stockton-on-Tees:

	German peat.	Italian peat.	English peat.
Moisture content, per cent	40–60	15	57.5
Nitrogen content, per cent	1	1.58	2.3
Gas from one ton of theoretically dried peat, cubic feet	35,000	60,000	90,000
Heat value, B. t. u., per cubic feet	150	166	134
$(NH_4)_2 SO_4$ per ton of theoretically dried peat, pounds	70	115	215

In the Mond gas plant, when coal was used, the producer was fed with a blast of air saturated with steam. This method required some slight modification when peat containing moisture was used, but this modification was simple enough. The problem had been investigated by Frank and Caro, and by others. It was obvious, he (Professor Baly) thought, that for successful economic work it was necessary that the plant be fed with peat which had not been specifically dried. It was perfectly possible to utilize peat containing as much as 70 per cent of moisture in a Mond plant, and this was fundamentally important since it allowed peat which had been air dried in the winter months to be used without any further drying. It had in fact been found that the nitrogen was recovered as ammonia more easily with a wet peat than with a dried peat, though the process was slower.

The following figures were typical of the results obtained with peat containing 50 to 60 per cent of water. One ton of theoretically dried peat gave altogether 88,000 to 92,000 cubic feet of gas. Of this, 39,000 cubic feet were used in the preheaters, leaving 49,000 to 53,000 cubic feet in excess. From this excess were developed 700 to 750 H. P. hours. Further, 70 to 85 per cent of the nitrogen was obtained as ammonia, and the yield of tar was 3 to 6 per cent. As regards the cost, the only published figure he had found, which was given at the inception of the process in 1907, was 0.118 cent per H. P. hour. At a later date, 1911, Caro gave some figures which illustrate the size of one of the German works. In the Selweger bog works in December, 1911, the output of electrical energy was 430,000 kilowatt hours, which represented a plant capable of producing 6,000 kilowatts. Each ton of theoretically dried peat in these works gave 1,000 H. P. hours and 90 pounds of ammonium sulphate. It was stated that the cost of working was nothing, as all expenses were paid out of the by-products. Peat containing up to 70 per cent of water was used.

When one came to consider the enormous deposits of peat in these islands, he trusted he had said sufficient to justify his statement that the time had now come to revise entirely our ideas as to the value of peat.

He had said nothing regarding the peat tar. There was no doubt that the Germans had been in the habit of distilling this tar and recovering valuable substances therefrom. Caro stated that the tar from the Selweger works was distilled and yielded 15 per cent of paraffin wax, and 50 per cent of neutral oils. This was vague, but we had the results obtained by G. T. Morgan in the distillation of tar from the plant of the Portadown works. Briefly, the results were as follows: The moist tar contained about 30 per cent of water and yielded about 50 per cent of volatile oils and a residue of nonvolatile, bituminous pitch. The volatile oils consisted of acidic oils, neutral oils and waxes. The first were obtained by washing the volatile oils with sodium hydroxide and reprecipitation by the addition of mineral acid to the alkaline extract. The acidic oils consisted of polyhydric phenols of very high germicidal power. The neutral oils yielded on distillation fractions boiling over 250 degrees, which deposited on cooling considerable quantities of an almost colorless wax, with a melting point of 35 degrees to 40 degrees.

In addition to the tar there were the soluble and volatile organic compounds, which included methyl alcohol and acetic acid, as well as pyridine bases. Finally, there was the ash which varied considerably with the peat, and lay between 5 and 15 per cent. Analyses of various samples of peat ash had shown that

they contained aluminum, calcium, magnesium and iron, as carbonate sulphate, silicate and phosphate. The alkali metals were also present, especially potassium. These facts suggested the use of the ash as a dressing for land. As Morgan pointed out, this would partake of the restoration to the soil of those very mineral constituents absorbed therefrom by the peat vegetation.

The chairman, in opening the discussion, said that the yield of ammonia that Prof. Baly had described as being got from peat was similar to that obtained in work which he (the chairman) had been connected with years ago. He was very much interested in the figures Professor Baly gave as regards the reduction of cost of power from peat. The figure he gave them was 0.118 cent per H. P. hour. If they got it at something more than that, they would be very happy, for the cost of power was increasing. He understood that an experimental plant of considerable size had been erected in Scotland and was working. He would be glad if Professor Baly could tell them anything about that, and if it were likely to be a commercial success. The production of paraffin wax from peat was tried some time ago, but did not come to anything.

Dr. E. F. Armstrong observed that as the price of coal went up, we should have to look around for some other fuel, and the value of peat was obvious. He thought they should all agree with Professor Baly that the extra cost would have to be paid for by the by-products. He thought that a good many present would feel that the cost figures put before them needed somewhat drastic criticism. The depreciation of a peat producer plant must be at least four times as much as that of a Lancashire boiler and that was not allowed for. He did not think they could get peat at $1.38 a ton at works. We should have to look to the by-products to bear the cost.

Mr. W. G. Polack, referring to the question the chairman had asked, respecting works in Scotland, said that those works had been closed down since the war began. The plant there had to be started on coal, and he understood that so many difficulties had been encountered before the war that no trial run was furnished long enough to get rid of the coal and therefore to determine the facts as regards the use of peat.

Mr. W. Mansbridge was of the opinion that the question was the nearness of a factory to the source of supply. In the case Professor Baly had mentioned, the peat was very cheap. He (the speaker) had been informed that at the Westmoreland mosses they could sell all the peat they had at $6.90 a load, which worked out at something like $4.84 a ton. It seemed to him that the by-products would have to pay the cost of every-

thing, and if that could not be done the thing could, he thought, hardly be a success.

Mr. P. de G. Coghill thought that the cheapest way of drying peat was that shown by Mr. Perry, of Dublin, about 30 years ago. They used to get the peat and bring it down by a railway which was covered to form a tunnel at the end. At the upper end of the tunnel, they had a chimney and at the lower end a fire. The trucks of peat, loaded in a very loose manner, were brought in at the upper end, and they went along the tunnel and came out at the other end with the peat nearly dry.

Mr. G. Carruthers Thomson said that when the peat had to be brought eighteen or twenty miles, it was found it could not compete with coal. If peat were used they must, he thought, take out the residuals. If they took into consideration the enormous quantities of shales from which oil could be produced it would come far and away within the cost of peat, and they could do it much more cheaply and the by-products would be very much more valuable.

Professor Baly, replying to points raise by speakers, said he did not really mean to suggest that any works in England, placed wherever they might be, should consider the use of peat producer plant for raising power. The figures he had given them were those of works directly on peat bogs, except at Portadown, where the peat was carried a dozen miles. At the other works, it was obtained within a few yards of the producers. Mr. Carruthers Thomson had said that peat had failed where they had to cart it, and that it was cheaper to cart coal. There were millions of tons of peat, there was more peat, he believed, in this country than there was coal anywhere. The whole of the success of Germany in this war was due to this—that they had been able to make the whole of their nitric acid from the atmosphere, and he suspected they were using peat. Why should they not go to the Minister of Munitions and say: "Give us works and we will produce synthetic nitric acid for you on the bogs of Ireland." If they could only get works erected on the peat bogs of Ireland, they could get power exceedingly cheap, and calcium carbide, calcium cyanamide, and heaps of things that were being done in other countries. He believed that with scientific intelligence and interest and with patriotic enthusiasm, great success might be attained.

(Chemical Trade Jour., Vol. 59, 1916, page 415.)

EXPERIMENTS WITH BACTERIZED PEAT-HUMOGEN.

(F. J. Chittenden—Bull. Agri. Intell., Vol. 7, 1916, page 651.)

Pot experiments with begonia plants (Begonia semperflorens) and wth Eupatorium adenaphorum grown in loam, in loam and raw peat, and in loam with bacterized peat, showed the fertiliz-

ing power of the last named in an unmistakable manner. Similar tests on seedling tomatoes gave a like result; it was, however, remarked that the increased development was confined to the aerial parts of the plants. The difference between the loam series and the loam and raw peat series was very slight, and that between the bacterized and the raw peat was too great to be ascribed to difference in water-retaining capacity. The hypothesis that the treated peat contains "activators" is supported by the fact that large doses of it caused very little increase but were not detrimental. Tomatoes were also grown in sand cultures and watered with extracts of bacterized peat, boiled peat, untreated peat, and with an ammoniacal extract of raw peat. None of the plants did well; and those treated with ammonical extract died within two days, and those that received the humogen grew to twice the size of the rest. Hence it is inferred that the particular virtue of this fertilizer lies in its water-soluble constituents. The results obtained in the field experiments were much less satisfactory. Radishes, turnips and French beans were grown in a very sandy soil, and dressings of two tons per acre were used for both treated and untreated peat. There was no difference in the growth of the plants in either, or in the control plot. "Early White Stone" turnips were cultivated in plots receiving (a) no dressing, (b) humogen one ton per acre, and (c) the same plus 150 grams of manganese sulphate. There was a slightly accelerated growth and a small increased yield in b but the increase was mostly in the leaves. In c the root and aerial development was balanced. The yield of dwarf French beans was 12 per cent greater in soil dressed with humogen, and 3 per cent greater in the same soil manured with untreated peat, than in the control plot. No visible effect attended the application of bacterized peat, at the rate of three tons per acre, on a grass plot measuring 10 by 60 feet. The effects of (1) humogen on turnips growing in a poor, unmanured soil were compared with those obtained by using (2) humogen and farmyard manure, (3) farmyard manure, (4) the same together with artificials, (5) no manure, (6) lime, (7) humogen and lime. Seven of the ten plots were watered artificially. The order of response for the roots only was: 7 (best), 5, 3, 2, and 4, 6, 1, and for the whole plants: 4, 7, 3, 2, 1, 6, 5. The watered plots as a whole did better than the unwatered, but in the latter the bacterized peat diminished the yield. Similar experiments performed in 1915 on radishes, grown under glass and in the open, and upon turnips, showed that as regards the weight of the roots, the effect of the fertilizer was negligible; it probably varies in the compositon.

Twenty tons or farmyard manure costing $38.72 (delivered) is better value than one ton of bacterized peat at $48.40.

(Tons used here are long tons, 2,240 pounds.)

IRISH PEAT DEPOSITS.

In the British House of Commons, Mr. Ginnell asked the Chief Secretary for Ireland whether his attention has been called to the deposits of peat in Ireland capable of manufacture, as in Sweden and Canada, into fuel for power and domestic use nearly equal to coal at one-third the cost, and into charcoal and valuable by-products, all hitherto prevented in the interest of British coal; and whether, in view of the high and growing price of coal, the Government propose to do anything to release this latent supply of cheap fuel and open up an Irish industry of great potentialities? Mr. Duke replied that the development of the Irish peat industry has not, so far as he was aware, been in any way prevented in the interests of British coal owners. Enterprise for the development of Irish peat deposits and the utilization of peat on a wider scale for power purposes would be welcomed, but the experiments which have been made appear not yet to have led to the discovery of suitable processes.

(Chem. Trade Jour., vol. 59, 1916, page 553.)

NORWEGIAN PEAT IN PLACE OF COAL.

Owing to the scarcity of coal, there was an increased production of peat in Norway in 1915. There are extensive peat deposits in the northern part of the country and the Government contemplates their exploitation. It is proposed to acquire land in the neighborhood of Christianssund, at a cost of over $1,000,000 and to secure the right to manufacture peat fuel under a British patent. Negotiations to that end have been in progress, the intention being to untilize the patent fuel for the Norwegian State railways. One new factory was built in 1915 and several old ones which had suspended operations were reopened. Most of them produce for local consumption only and the quantity which reaches the general market does not exceed 10,000 tons. The average price of peat was about $6.70 per ton f. o. b. works in 1915. There is said to be a demand for more modern machinery and methods of work, owing to the growing scarcity of labor.

BACTERIZING PEAT FOR MANURIAL PURPOSES.

(W. B. Bottomley, Br. Pat. 16658, 1915.) In a previous specification the inventor described a method of treating peat, consisting in subjecting it to the action of aerobic micro-organisms capable of producing ammonia, the effect of which is to

convert the humic acid and humous bodies contained in the peat into compounds soluble in water. By the present invention the time occupied in the treatment of the peat, generally about three weeks, may be shortened by first neutralizing the peat by means of any suitable alkaline body, such as sodium carbonate. Thus the peat may be treated with a solution containing 1 to 1.5 per cent of its weight, when air-dried, of Na_2CO_3, and then subjected to the bacterial treatment as previously described. The process may be still further hastened by suitably heating the neutralized peat such as by blowing live steam, preferably under pressure, through it for a half hour to an hour, before the bacterial treatment. The best procedure at present known is alternately to sprinkle with a solution of sodium carbonate and to turn over a layer of peat, say, 6 inches deep until a quantity of soda ash, amounting to 3½ per cent of the weight of the anhydrous peat, dissolved in about five times its weight of water, has been used. The peat is then charged into tank containing perforated pipes, through which steam at about 60 pounds pressure is blown until the temperature of the whole mass is slightly above 100 degrees C., which generally happens in about half an hour for a ton of peat, the tank being loosely covered. The action of the heat on the neutralized peat is to break down the cellular tissue. The peat is now spread in a layer about a foot deep on a suitably heated floor, and sprinkled with water containing ammonia-producing and nitrogen-fixing organisms; it is then kept for about three days at about 26 degrees to 28 degrees C.

SOME FACTORS THAT INFLUENCE NITRATE FORMATION IN ACID SOILS.

(E. B. Fred and E. J. Graul, Soil Sci., 1916, Vol. 14, p. 317.) Four representative types of Wisconsin soils were used: (1) a neutral silt loam, (2) an acid sand, (3) an acid silt loam, and (4) an acid peat. The last three required respectively 13,050 pounds, 20,420 pounds, and 5,985 pounds of calcium carbonate per acre to neutralize the top 6 inches of soil. All four types were found to contain nitrifying organisms; when, however, they were inoculated into a culture medium, the two silt loams nitrified much more rapidly than the sand and peat. In the soils themselves nitrification was very slow in the acid sand and peat, although the production of ammonia from casein in these soils was very rapid. In the silt loams nitrification was much more rapid. The form of nitrogen seems to play an important part, organic nitrogen being more readily nitrified in acid soils than ammonium sulphate, whilst in nonacid soils the reverse is observed. These results and the fact that the source of the nitrifying bacteria is immaterial indicate that acid soils are not pro-

vided with nitrifying organisms especially resistant to acidity. When organic nitrogenous compounds are present, addition of calcium carbonate has a temporary stimulating effect on nitrification which is reversed later on, coincidently with a great increase in nitrate-assimilating bacteria. The conclusion is drawn that, under laboratory conditions, the beneficial effects of calcium carbonate on plants are not due to the direct effect on nitrification, which takes place before the plants require large amounts of nitrates. The rapid accumulation of nitrates, due to liming, may, however, result in a loss of nitric nitrogen through leaching.

THE USE OF PEAT IN THE INDUSTRIES.

(B. Wigersma, Chem. Weekblad, vol. 13, 1916, p. 36.) A reply to Cerschoor, see this Journal, vol. 9, 1916, page 188. W. first takes exception to V.'s statements that burning on the flat grate under boilers is the least economical way to use peat. In the Groningen peat colonies the grates are made about one-third larger than for coal and built lower. They are fired by hand and the space from front to back of the grates and clear up to the boiler surface is filled completely with peat. The fuel is burned with the fire doors closed. The coking takes place slowly and uniformly, the thick bed of fuel gives thorough contact between air and fuel, and as the combustion takes place beyond the fire bars to a large extent, there is no clinkering nor burning of the grates. CO_2 in the stack gases is 13 to 14 percent, without any products of incomplete combustion. If the load is not allowed to exceed 16 to 18 kilograms of steam per square meter of heating surface, the CO_2 will not be below 12 percent. With hand firing of coal the CO_2 will 8 to 9 percent, so that though the price per calory may be higher with peat than with coal, the net result is more economical. Tests ran as follows: (Peat = **a**; coal = **b**). Heating value : (**a**) 3865 cal. per kg. with 17.8 percent H_2O, (**b**) 2700 calory; boiler surface: (**a**) 292 m); (**b**) 392 m); steam pressure, 5atm. for both; efficiency [(heat put into steam) (heat in fuel)], (**a**) 66%, (**b**) 65.8%; evaporation at 212 deg. F. per kg. fuel from **a** 4.71 kg., **b** 8.67 kg.; av. CO_2 (**a**) 12.3%, (**b**) 9%. W. also considers that V has averestimated the value of produce-gas power plants, and thinks that they are too unreliabe to compete with boilers and steam engines or turbines. In Holland the main industries in the peat-producng districts are those depending on agriculture, as potato-flour and straw-board factories. These need large quantities of exhaust steam for drying and are less suited for gas power plants. The future of large central power plants operating gas engines on producer

gas from peat he thinks very doubtful. Suction plants of less than 100 horsepower are practical.

EXPERIMENTS WITH "HUMOGEN" OR BACTERIZED PEAT.

(J. A. Voelcker, Intern. Sugar Jour. vol. 18, 1916, pp. 472-475). From pot culture experiments and from those conducted in the field, the author concludes that under conditions such as those obtaining in greenhouse cultivation, and where plants can be regularly watered and tended, a good preparation of "humogen" may produce a very marked increase in the growth of the green parts of plants and in the growing of green crops, but it will show practically no benefit in the production of grain. Under natural conditions of crops growing in the open, it has not as yet been established that, as regards the ordinary corn crops of the farm, any advantage is likely to accrue from the use of humogen when used in quantity such as a farmer is likely to be able to afford.

PEAT AND LIGNITE FOR USE AS FUEL.

(C. Melhardt. U. S. Pat. 1,205,007, Nov. 14, 1916.) The calorific value of peat or lignite is increased by heating in a closed vessel to 180 to 250 degrees C. for 8 to 10 hours to drive off H_2O and some gases, including CO_2, and then shifting out the ashy portions of the treated material in water or a salt solution.

PEAT FOR HORTICULTURE AND AGRICULTURE.

(J. J. A. and H. C. S. Whalley Br. Pats. 14,487 and 17,848, 1915.) Black or dark peat is treated with just sufficient ammonia to render it slightly akaline, and then 5 to 20 per cent of its weight of calcium carbonate, or similar substance, is added to prevent subsequent development of acidity. The ammonia may be generated within the peat mass by the action of an alkali, alkali carbonate or alkaline earth upon an ammonium salt, both ingredients being added directly to the peat and well stirred in. Thus, for example, one ton of partly dried peat, containing about 35 per cent of moisture, may be mixed with 2 cwt. of ammonium sulphate, either solid or dissolved, and 2 cwt. of powdered potassium carbonate, and subsequently with 1 to 4 cwt. of calcium carbonate. The fertilizing value may be enhanced by the addition of potassium compounds, phosphates, etc.

WET CARBONIZING (LTD.)

In 1912, after a preliminary syndicate had been at work, a company entitled Wet-Carbonizing, Limited, was formed, with works at Ironhurst Dumfriesshire. The capital, which was twice increased, now stands at £506,283 ($2,450,407.72), divided into 500,000 preference shares of £1 each, and 125,079 ordinary shares of 1 shilling each. There were issued, subject to payment wholly in cash, 423,537 preference shares and the whole of the ordinary shares already named. A large peat area was secured at Ironhurst, but it is stated that the process was never a commercial success. The works are closed down at present, and from the last balance sheet it appears that of all the cash subscribed only £2,725 ($13,189) remained.

IMPROVEMENT OF HILL AND PEATY PASTURES.

Experiments on the treatment of poor pasture on hilly or peaty ground were commenced in 1913 at 7 centers, an additional 8 centers being added in the winter of 1914-15. At each center seven one-quarter acre plots received various manurial dressings. The results so far show that basic slag is likely to produce at least as good results as any other manure. Gafsa phosphate, a form of mineral phosphate, will, on sour, peaty soils, produce almost as good an effect as basic slag. Potash manure has not given a return at all commensurate with its cost, while lime and ground limestone used alone have had practically no effect on the herbage.

(Jour. Bd. of Agri., 1916 vol. 23, p. 495.)

PREPARATION OF PEAT FOR FUEL.

(E. A. Patterson, Br. P. 2530, 1916.) Superfluous water is removed, the material is disintegrated, neutralized if necessary, by addition of an alkaline substance, mixed with alkali silicate solution, with or without the addition of solutions of boric acid and calcium chloride, moulded into bricks or the like, and dried.

CANADIAN PEAT DEPOSITS.

According to telegraphic information received at the offices of the High Commissioner in London for Canada, peat available for commercial exploitation in the Dominion has been located in one district covering 140,000 acres. It is estimated that from this area 115,000,000 tons of fuel could be procured. Seven deposits of peat in the Montreal district and a like number in On-

tario are considered to be capable of yielding 23,500,000 tons and 26,500,000 tons of fuel, respectively.

STUDY OF NITROGEN RELEASE BY AZOTOBACTER.

(T. Moler, Experiment Station Record, vol. 34, 1916, p. 627.) The author has devised and employed a culture filter apparatus, which is said to permit the removal and separate examination of metabolic products from bacterial cultures. It is stated that A. chroococcum during its life separates no soluble nitrogen compounds; only after death does it furnish nitrogen to higher organisms. Starvation brings this organism into resting condition. Proteolytic bacterial enzymes are entirely ineffective toward the nitrogenous compounds contained in this organism. The presence of such compounds in cultures is to be explained as due probably to the activities of amebae which use it for food. A. ggile and A. wienlandii behave in a different way, both separating soluble nitrogen compounds.

UTILIZING THE RESIDUES OF PEAT FIBER AS FUEL.

(Leo Ubbelohde, Ger. Pat. 294,142, 1915.) The peat residues obtained after separating peat fiber by the wet method, which consists of plant parts and slime, are mixed together, dehydrated, and then briquetted.

THE NATURE OF THE INJURIOUS SULPHUR TO PLANT GROWTH IN PEAT SUBSOILS.

(W. Thorner, Ztscher. f. Angew. Chem., vol. 29, 1916, p. 233.) The, for plant growth, injurious or so-called reactive sulphur is not only present in peat soil as pyritic sulphur, but also in a free state and probably also in organic compounds. This reactive sulphur is perfectly harmless as long as it is below the water line of the peat deposit. If the water level of the bog is lowered, however, or if the peat is dug up, an oxidation of the sulphur is created by the oxygen in air and the water vapor. This oxidation is energetic in the case of pyrites, whence iron sulphate and sulphuric acid is formed. With free sulphur it takes place more slowly and sulphuric acid is formed directly. These oxidation products disturb plant growth and react with lime and concrete. In peat fiber, the finely divided sulphur is slowly oxidized to sulphuric acid while the water is evaporating, which is accelerated probably by the presence of oxidizing compounds present during the evaporation, as ozone, hydrogen peroxide and oxygen energetically convert the finely divided sulphur in water, in statu nascendi, to sulphuric acid.

PEAT AS A SOURCE OF POWER IN GERMANY.

Now that it is possible to convert inferior fuels, such as peat and brown coal, with a relatively high degree of efficiency, into gas by generators and to make practical use of them as sources of power, the interest in them is increasing. In northern Germany, where water power is not easily available, the high and low bogs are destined to furnish the fuel needed for the generation of electricity. The experiences of the overland power plant in the Auricher Wiesmoor have proved that with a peat consumption of 2 kilos (4.4 pounds) per kilowatt-hour the peat bogs are an economically useful source of power of great extent and duration.

With an annual supply of current amounting to 24,000,000 kilowatt-hours, the high bog at Aurich (Prussian Province of Hanover), having an area of 10,000 hectares (24,710 acres), could furnish fuel for 700 years. This particular power plant is destined to supply electric current to all Ostfriesland, the Grand Duchy of Oldenburg, and adjacent territory. The area of the peat bogs in the German Empire has been estimated by the Society for the Promotion of Peat Bog Exploitation to be about 2,300,000 hectares (5,683,400 acres). Their exploitation will not only make available a valuable source of power, but will also promote the interests of agriculture.

PEAT FUEL IN CANADA, 1915.

Shipments of peat for fuel purposes in Canada in 1915 amounted to 300 tons, valued at $1,050, as compared with 685 tons, valued at $2,470, in 1914.

PEAT IN CHINA.

A peat deposit reported in Fuiken Province, about 80 miles from Amoy, China, shows the following analysis:

Volatile matter	61.52
Fixed carbon	24.77
Sulphur	1.1%
Ash	12.52

HUMUS-CARBON AND NITROGEN.

(R. A. Gortner, Soil Science, 1916, vol. 2, pp. 395, 539.) Eight mineral soils, 3 peats and 5 samples of unchanged vegetable material, were analyzed for total C and total N. The soils were also analyzed for C and organic matter soluble in 4 per cent NH_4OH and 4 per cent NaOH both before and after

leaching with 1 per cent H.Cl. The materials extracted from the soil by NaOH and by NH_4OH were found to differ in amount and composition. From any one soil after leaching with 1 per cent HCl, NH_4OH will extract less C and at the same time more color that will NaOH. The vegetable materials contain much more N soluble in 1 per cent HCl, while soils contain only a small quantity, and on the other hand the soils contain an appreciably amount of N insoluble in 4 per cent NaOH in contrast to the unchanged vegetable materials. A soil pigment was found in the mineral soils and in a calcareous peat which was not found in the acid peats or vegetable materials. The pigment is black and contains only a small proportion of the soil N. G. concludes that (1) the humus extract of soils is not a typical soil product formed in the soil by a specific humification. but that similar products can be obtained from unchanged vegetable material; (2) humus does not consist entirely of a black compound or compounds, but contains a large proportion of colorless substances whose presence is masked by the black color; (3) the common practice of comparing humus N determined in a NaOH extract with humus extracted by NH_4OH can give only meaningless results; (4) 4 per cent NaOH extracts almost as much N from the unbleached soil as from the soil after leaching with 1 per cent HCl; (5) the determination of humus as ordinarily carried out (extracting with NH_4OH) appears to be wholly without scientific justification. An apparatus for the accurate determination of C by wet combustion is shown. A review of the literature is given. An attempt was made to isolate the pigment from soils in a pure loam. A silt loam soil was leached with 1 per cent HCl and then extracted 9 consecutive times with fresh portions of a 4 per cent NaOH solution. A sample of the residual soil was analyzed at this point. while the remaining portions were further extracted 6 consecutive times with a 0.15 per cent NaOH solution. After this the soil was analyzed. It was found that a 4 per cent NaOH solution does not dissolve the black pigment. The soil pigment is soluble in very dilute NaOH solutions, but precipitates on addition of a 4 per cent NaOH solution. The soil pigment is also precipitated from solution by salts of the heavy metals and by acidification. It is not dialyzable and forms a stable, water-soluble compound with NH_4OH when an ammoniacal solution is evaporated to dryness. The analyses of the product with the least ash content gave C 61.3, H 4.3, N 2.8, O 31.6 per cent calculated to ash-free basis. The first 6 extractions with NaOH removed relatively more N than C from the soil, but the remaining 3 NaOH extractions as well as the 6 pigment solutions contained relatively more C than N. The final soil residue had a C/N ratio much higher than that of the original soil.

PEAT POWDER AS LOCOMOTIVE FUEL.

(Engineering, 1916, vol. 102, p. 387.) Peat is being utilized from the Swedish deposits as locomotive fuel. The powder is carried on the tender in a hopper having a conical bottom. Beneath the hopper is a pipe through which the peat powder is blown by compressed air to a nozzle opening into the firebox. On entering the firebox it is ignited by a small coal fire under the nozzle. The consumption of coal for this purpose averages 3 to 4 per cent of the weight of the powder used. Tests were made on two locomotives of the same type, peat powder being used in one and coal in the other. The peat averaged 7,920 B. t. u. per pound and the coal 13,030 B. t. u. per pound. The program for the tests stipulated for a freight train of 700 tons weight being run at normal service speed (22 miles per hour). On the last journey the train was composed of bogie passenger cars of a weight of 300 tons, and the speed was 34 miles per hour. The super-heat temperature of the steam was higher with the locomotive fed with peat powder fuel than with the one using coal. The boiler efficiency and firebox temperature gave for the locomotive for peat powder 73 per cent and 1,670 degrees, and for the locomotive using 68.8 per cent and 1,510 degrees. This shows that the heat value of the peat powder is better utilized than that of the coal. The same quantity of steam could be obtained from 1.45 pounds of peat powder as from 1 pound of the coal used, and with a supply of 4 tons of peat powder a freight train of 650 tons and a passenger train of 300 tons behind the tender could be hauled respectively 62 and 81 miles.

PREPARING PEAT.

(J. W. Hinchley and G. Gordon, Br. Pat. 3998, 1915, and Br. Pat. 101, 782, 1915.) A mixture of peat composed of the upper and lower layers of bog, containing a substantial quantity of fiber, is subjected, without preliminary heat treatment and at ordinary temperature, to a pressure of about 1,000 pounds per square inch, preferably in a hydraulic press. The pressure is reduced to about 200 pounds per square inch and steam or hot air at this pressure is forced through in a direction at right angles to the movement of the press. A final pressure of 1,100 to 1.500 pounds per square inch is then applied to express as much of the remaining liquid as possible. The resulting cake may be used as fuel, or carbonized for the production of by-products. A press suitable for the process described comprises a hydraulic cylinder, ram, and rods, supporting an annual piston. The inner walls of the pressing cylinder have longitudinal grooves covered by a wire-gauze strainer. A cover carries rollers

which run on rails so that it may be removed when the cylinder is to be charged. Steam or hot air is admitted by the passage, to the conical outlet which is perforated and covered with a wire gauze strainer and perforated cap. Steam and condensed water are discharged through the strainer and pipe. During the preliminary compression expressed liquid is discharged through the strainers and pipes. In a modification, the pressing cylinder is provided with an additional annular grooved wall with strainer, and an additional annular steam nozzle, both reaching nearly to the top of the cylinder. Three annular concentric pistons are then used, while the communicating space at the top equalizes the pressure. The steam tube is secured to the support by a screwed cap to minimize the height of the press.

Journal of the
American Peat Society

VOL. X JULY, 1917 No. 3

The Annual Convention and the Present Crisis

Several of our national Scientific Societies are, on account of the war, either cancelling or postponing their coming annual meetings.

The executive committee of the American Peat Society has received suggestions which tend to have this committee adopt a resolution to postpone our coming annual convention. The executive committee is therefore giving this matter very serious consideration but would like to hear from our members what they would suggest at this time. In the meantime preparations are still going on for the proposed annual meeting at Minneapolis on Sept. 21-22 next.

ADDITION TO EDITORIAL STAFF.

The executive committee of the American Peat Society, because of its realization that the large amount of work entailed in publishing our journal falls largely on the shoulders of the editor, has invited Henry Clay Lint, Ph.D., to act as Associate Editor. Dr. Lint has gracefully accepted the invitation. Dr. Lint is exceptionally capable in the agricultural and bacteriological work connected with peat. He has spent four years at the Kansas Agricultural College, and for three years held the Sulphur Research Fellowship in the New Jersey Agricultural College, where he started bacteriological research work, and he is now conducting important bacteriological work in cooperation with Dr. Mann at the Delaware Agricultural College.

Dr. Lint will not only act in an advisory capacity but will also contribute material to our Journal.

THE FUTURE FOR BACTERIZED PEAT.

If it were always possible to prophesy accurately the future of any product or industry there would, of course, be no failures in business or differences of opinion. A thorough knowledge of the product and an unbiased perspective of the demands for it are prime requisites for sound judgment.

Much interest has been shown in bacterized peat both by our own membership and the general public. To what dimensions such industry may expand and become a large factor in plant fertilization is one of the most important conjectures in the minds of those interested in the commercial use of peat. To the scientist the problem offers a field most enticing because of its possibilities in research.

It is understood that statements favorable to properly prepared bacterized peat do not apply to the raw products from which it is made. Little besides a physical action is exerted by the crude products and the public must be brought to appreciate the distinction between the prepared and the unprepared products if the fullest satisfaction is to be obtained by the purchasing public.

But to return to our object, which is to analyze the factors tending to cause a wider production and use of properly prepared bacterized peat. It is conceded as a basic principle of soil fertility that soils must contain a certain porportion of organic matter if they are to be abundantly productive.

The inferior quality and decreased quantity of manure which up to the present has been the chief supply for soil organic matter has made imperative that a substitute be found. The almost complete utilization of meat tankages in animal feeding stuffs has robbed the fertilizer maker of one of his most prized ingredients. Both the beneficial results which have followed the use of organic ammoniate fertilizers in the soil and also the improvement in the physical condition of mixed fertilizer has made tankage or dried blood a necessity with the manufacturers.

As prepared today under the most advanced methods, bacterized peat gives several times the organic residue, ton for ton, produced from manure, and if properly balanced with minerals it shows to even better advantage on the basis of chemical analysis.

As an organic ammoniate for chemical fertilizer mixtures it is not improbable that peat and muck can be so prepared and bacterized that it will completely fulfill the demands made upon it. Quite probably it will be found most difficult to ever bring the nitrogen content up to that of the high-grade tankages of today but that fertilizer manufacturers will be able

to so modify their formulæ as to use high-grade bacterized peat or humus tankage there can be little doubt.

From the physical standpoint the higher content of organic matter in such mixed goods would render them much better than the commercial fertilizers now produced. It is also quite probable that because of the great absorptive properties of the large quantity of organic matter in such mixtures a more efficient utilization of the purely chemical ingredients would result.

It is quite apparent therefore that a good future exists for commercial bacterized peat as an organic ammoniate and also directly as a means of supplying humus to the soil. In view of the excellent results that have been obtained and also the fact that in the peat and muck deposits we find the one last source of organic nitrogen that exists in large enough quantity and is at the same time inexpensive, there can be no doubt that the future has reserved a favored niche for bacterized peat to fill.

From the standpoint of the research scientist the future for bacterized peat is filled even more to overflowing. Some very excellent products have been prepared, and assuming that no improvements were possible, bacterized peat might be able to fill all the requirements asked of it.

The object of all peat and muck treatment has been to either render the original nitrogen more available, make the nitrogen content higher, or both. To render the nitrogen more available the activities of various ammonifying bacteria have been called into play. Various basic and nutrient materials must be added before peat or muck becomes an entirely congenial habitat for such organisms. The initial narrowness of the carbon-nitrogen ratio also tends to make such material resistant to decomposition.

That certain organisms after certain reinforcement of the peat or muck are able to bring about this beneficial transformation is beyond doubt. To what extent our best means of treatment can be improved through the utilization of new strains of bacteria or other methods of reinforcement remains for the future to bring forth.

An increase in the percentage of nitrogen can be brought about in two ways—(1) by the decomposition of carbon and (2) by the addition of nitrogen. Certain well-defined species of bacteria can do either of these things. Many investigators have noted an increase in the content of nitrogen but whether it came about in the first or the second of the two possible ways is not established. Just how much of an increase in nitrogen can be effected through the activities of azotobacter

in a peaty residue already rich in nitrogen is a problem for the future to reveal.

Perhaps the largest function of bacterized peat will lie in its carrying to the soil a beneficial flora. No matter to what extent bacteria may have developed during the processes of treatment, it is quite essential that they be not destroyed during the later processes of manufacture. That the process of thorough bacterizing will be successive and that one type of flora will replace another appears most logical. Manns has shown that, when properly composed, peat or muck can be made the carrier of a very beneficial type of soil flora, and it should be the ideal of every producer to have the final product richly impregnated with the beneficial organisms.

To what extent such organic bodies as Oximones are developed through the activity of bacteria in peat and to what extent they stimulate plant growth, if at all, is one of the richest fields for investigation in plant nutrition and physiology.

It has appealed to many a priori that the enormous deposits of peat and muck have been placed there for a purpose and now that the problem of organic ammoniates is most acute, they are turning in numbers as never before to this vast, undeveloped resource for their materials. In the scientific way we have had only a glimpse at the possibilities and just in proportion as muck and peat is improved through bacterial preparation must the commercial side thrive.

The Industrial Chemist and the Fertilizer Crisis*

By H. CLAY LINT, Ph. D.

Perhaps at no time in its comparatively brief history has the fertilizer industry been confronted with more serious problems. In seeking the reason for this situation by studying every item which helps to maintain the unstable commercial fertilizer equilibrium, we arrive at the same causative factor—war.

This industry draws the raw materials from which its finished products are prepared from all corners of the globe, and with practically all of these various corners embroiled in war, it is only natural that great difficulties should be encountered. Like the curing of any disease, whether personal or commercial, there exist but two methods of cure: the removal of the cause, or the finding of a remedy. In the present case, the removal of the cause is an impossibility, so that our efforts must necessarily focus upon remedial measures.

The chemistry of the fertilizer manufacturer includes but three elements; nitrogen, potash and phosphorus. When the handling, however, reaches into the millions of tons, the small number of elements concerned assume a mien of greatest importance.

Thanks to wide newspaper comment, it is now common knowledge to the layman that practically all of our potash supply came from Germany. Chemists were quick to realize the necessity for prompt action in producing potash salts from domestic sources the moment overseas shipment from Germany ceased. To date, the chief sources of supply for domestic potash, according to the latest report of the United States Geological Survey, have been as follows:

Some Domestic Sources of Potash.

Mineral sources: Natural salts and brines, 3,850 tons; alunite and silicate rocks, including furnace-dust recoveries, 1,900 tons; making a total derived from mineral substance of 5,750 tons. The data are for the 1916 output, which in value is ten times that of 1915, showing to what extent the production increased during the last year. Allowing for unreported

*Research Chemist and Bacteriologist, Alphano Humus Co., 17 Battery Place, New York City.

†Reprinted from the Chemical Engineer, Vol. 25. 1917, p. 86.

sources, there were about 10,000 tons of K_2O produced, valued at $3,500,000.

From organic sources, 1,110 tons came from kelp. Twenty-three out of a total of seventy producers report a total tonnage of 220 derived from wood ashes. Miscellaneous industrial wastes contributed 1,750 tons, making a total from organic sources of 3,080 tons. The greater part of the mineral supply was obtained from the Nebraska alkali lakes. Late reports show that the large modern plant of the Pacific Coast Borax and the Solvay Process companies situated at Searles Lake in California are ready to start operation. The output from this place is estimated at 1,000 tons per month, which in itself practically equals the production of last year from all sources.

The most generous estimate for 1917 production, however, does not measure up to the huge industrial and agricultural demand for potash, so that while an admirable start has been made, still the potash problem may be looked upon as unsolved.

A Nut for the Chemist to Crack.

The one big, almost inexhaustible supply of potash in this country lies in orthoclase, or potash feldspar. To render this potash available, and at a cost that would make the process commercially profitable, is one of the problems that the industrial chemist has yet to solve. It is true that a great amount of work has been done, but none of the processes are above objection. It appears a priori that in some way this can be accomplished, and that orthoclase potash can be put on as big a commercial basis as the acid phosphate industry.

Industrial waste products can undoubtedly be made to yield a rich return in potash fertilizers as a result of improved methods to be worked out by the industrial chemist. Here again the limiting factor of costs is the shackle that must be broken in many instances. A better conservation and possible concentration of wood ash might easily make this source of supply of greater importance, but such work is more a matter of engineering than of chemistry. Converting the insoluble potash of wood ash into available form is a chemical phase of any wood ash work to be considered.

The close sighted layman sees no excuse for phosphorus shortage when told of our wonderful resources of this material. He fails to appreciate the vital importance of acidulation, and it is this chemical phase of production that has made the situation acute. The chief factor is that of interrupted commerce, and the traffic manager may be a more important person than the chemist as far as phosphoric acid is concerned.

Transportation Presents Serious Problem.

Coastwise traffic is greatly curtailed, due to the diverting of vessels to European channels. Rail transportation has necessarily increased to European channels. Car shortages all over the country have made the moving of materials most difficult. This is particularly so because of the present imperfect service of the Southern railroads, over which practically all phosphate rock must move.

A transportation factor that is influencing a more strictly chemical phase is that of a practical stoppage of the importation of iron pyrites from Spain.

This means that many of the big acid plants will be forced to remodel in order that they can use elemental sulphur. The enormous demand for sulphuric acid in the manufacture of munitions has practically doubled the cost of this article, so that we see a second legitimate reason why the cost of acid phosphate should be increased.

Raw rock phosphate has quite generally given less profitable results than those obtained from the acidulated material, and the difficulty cannot be eliminated by so happy a suggestion as the use of raw rock. Dr. Lipman, of the New Jersey Agricultural Experiment Station, has worked out a composting method, whereby sulphur, acidized by bacteria, forms sulphuric acid in the soil. By having this action take place in the presence of phosphate rock, the material is made available. About 60 to 75 per cent of the total phosphorus is utilized.

Considering the nitrogen conservation, the method recommends itself under many conditions. Many florists and truck gardeners annually prepare their compost piles, and where facilities are available, it is practical for farmers to add the proper amount of sulphur and floats to animal manure. Five parts of sulphur, fifteen parts of floats were added to one hundred parts of soil in the work reported by Lipman.

U. S. Must Face Nitrogen Situation.

The situation as regards nitrogen is fully as serious as that of potash. Imports of sulphate of ammonia and cyananid from Europe are practically cut off. Scarcity of ships for bringing nitrate of soda from Chili has greatly curtailed the importation of this material and forced a corresponding rise in the price. The fuller utilization of animal matter by the packers for foodstuffs has cut down on production, but the more serious aspect of the shortage has been brought about through the increased usage of organic ammoniates

for animal feeding purposes. At present, any animal ammoniate is worth practically $5.00 a unit—with none on the market even at that price. Garbage tankage, which only a few years ago was considered greatly inferior, is now costing over $4.00 a unit, and the supply is short of the demand.

Great seriousness is attached to the organic ammoniate problem, because of the fact that the delectable status quo ante bellum will not be re-established by the treaty of peace. In fact, it can almost be stated that the day has passed altogether for the utilization of high-grade animal tankages by the fertilizer industry.

Recently, many of the best chemical and biological minds have turned toward peat and muck as a source of supply.

Availability of Peat.

Peat exists in tremendous quantities in all quarters of the globe. It is rich in nitrogen and carries an abundance of organic matter, the presence of which is so essential to soil fertility.

When the absolute necessity of organic ammoniates is considered, together with the enormous quantities of muck material now conserved in the form of peat and muck, it would seem that Providence had expressly decreed this state of affairs.

Let us not infer, however, that all that is necessary is to dig raw peat or muck, use the same as animal or blood tankage, and obtain as beneficial results. Far from it, and it is this field that now opens up new opportunities to the industrial and biological chemist.

To fully understand the situation and its possibilities, it is necessary to consider the method of formation of these peat and muck deposits, and to consider this in the light of the function of decaying organic matter or humus in soils.

The normal cycle of organic matter calls for the synthesis of compounds by plants through the energy derived from the sun. After death, the products so formed are decomposed largely through the activity of micro-organisms, eventually becoming the same compounds from which the complex organic body was first formed.

But for the existence of unfavorable environmental factors, this same fate of complete decomposition or mineralization would have befallen the vegetable matter now conserved as peat and muck. Anærobic conditions produced by the large quantity of water and organic acid formed by the decomposition are probably the chief agencies which have prohibited complete mineralization.

The problem of economic and beneficial utilization of the organic nitrogen of peat and muck concerns itself therefore with the rectifying of conditions so that the cycle of decomposition, interrupted for ages because of adverse conditions, may again be renewed.

Problems of Peat Utilization.

Obviously the first essential is to remove the excess water through drainage. Secondly the acidity must be corrected. Of even greater importance however is the fact that a proper microbial flora must be introduced. Through all the years that the peat has laid under unfavorable conditions, the original flora has been replaced by inferior species of microorganisms. The beneficial types of decomposition are accomplished by more or less well defined microbial species, and these must again be introduced to complete their interrupted labors.

In England, thanks to wide newspaper comment, Bottomly has been able to show the benefits and results obtained from peat treated according to his special prescription. In essence, his method consists of introducing a decomposing flora after having first rectified the acidity. Upon the completion of this process, the material is sterilized and a new flora, consisting largely of the independent nitrogen gatherers (Azotobacter sp.), is introduced. Making use of the organic substance first produced, these organisms fix additional nitrogen from the air. The product has been tried in only a small experimental way, and even though the process is entirely revolutionized in the light of further research, it marks a step in the right direction.

In this country, Mr. Hoff, of the Alphano Humus Company, was probably the first to appreciate the possibility of the utilization of such organic nitrogen. His method of preparation is much more comprehensive and concerns itself with the physical state of the material as well as the chemical and bacteriological.

Cultivation of the Deposit.

The first step is naturally that of drainage and proper clearing of the deposit. Crops of onions, lettuce and celery, to which such formations are admirably adapted, are grown for four to ten years. During this time heavy applications of lime, potash and phosphorus are made in order to thoroughly rectify conditions for the best microbial development as well as the higher plants.

The benefit brought about through cultivation is such that the mass is finely disintegrated, and upon drying it is

much like dried blood from the physical standpoint. As prepared commercially by Mr. Hoff, the surface layers are removed by means of electric scrapers after thorough sun drying. The material is removed to a big compost pile containing from twenty to thirty thousand tons.

Just enough bacterial life exists to cause a mild beating without fire fanging, and the introduction of the proper types of bacterial life as well as proper chemical substance to favor that life was one of the biggest problems that confronted the industry. At present, a very satisfactory method treatment has been worked out, but it still demands much study even after ten years of investigation. One trained in both chemistry and bacteriology is required for any type of investigational work in this field.

Introduction of Nitrifying Bacteria.

After composting, the material is passed through hot air driers and only enough moisture left to favor the persistence of the microbial population remains. A new flora consisting largely of the nitrifying bacteria, the independent nitrogen gatherers (Azotobacter), and the symbiotic nitrogen gatherers (Radicicola) are then added, together with other chemicals which render the material more conducive to their development.

These organisms probably constitute the best type of beneficial flora and are present in numbers ranging from two to five hundred million per gram.

To what extent chemical fertilizers can be combined with such material without destroying the beneficial flora is an important problem to be solved in connection with the utilization of prepared humus as an ingredient of mixed fertilizers.

If we are to draw any lesson from the study of the past fertilizer history, it would point to peat and muck as the coming source of organic ammoniates. The use of animal tankage was at first ridiculed as rank folly, but gradually it has become the most highly prized fertilizer ingredient. Garbage tankage experienced the same ridicule, only to come to a position but little less esteemed.

Peat and muck nitrogen has had even more serious prejudice to overcome, but with diligent research and with the aid of proper bacterial and chemical treatment, the material will become just as highly valued. It is the one last source of organic ammonia that exists in large enough quantity and is at the same time cheap enough to make its use as a fertilizing material possible.

Because of the fact that this problem of organic nitrogenous fertilizer has come to stay and will not be alleviated with the termination of the war, it would seem that it offers one of the richest fields for investigation by the industrial bacteriologist and chemist.

Report on Humogen*

E. J. RUSSELL, D.Sc.,
Director of the Rothamsted Experimental Station

Humogen is the name given to a preparation of peat invented by Professor W. B. Bottomley, of King's College, London, for which high manurial value has been claimed. The substance is prepared by neutralizing the peat and then causing it to undergo bacterial decomposition up to a certain point, after which the mass is sterilized and inoculated with a culture of nitrogen-fixing organisms.

Survey of Previous Experiments.

Experiments made at Kew with plants in pots gave extraordinary results, suggesting that humogen had some positive, definite action on plant growth. These experiments have been several times described, so that no further account is necessary. The humogen was used at the rate of 1 part to 7 or 8 parts of soil by volume, a quantity that is quite feasible in pot work, but out of the question for agriculture.† Pot experiments with these large amounts were also made at Wisley, and definite increases in growth were obtained which, while in no way sensational, showed that the material is of value to the horticulturalist growing plants in pots where economic considerations do not come in. This result is quite intelligible; the addition of so large an amount of organic matter in so fine a condition as humogen could hardly fail to have a good effect on the soil in a pot, while the large amount of nitrogen thus introduced adds to the supply available to the plant.

Other experiments, however, led Professor Bottomley to believe that such large quantities were not necessary and that much smaller amounts would give equally good results. In a paper read before the Royal Society in 1914 he claimed that an extract of this humogen had remarkable stimulating effects on the growth of plants, which he considered to be analogous to those obtained by Hopkins and others with the so-called accessory bodies; he therefore supposed that some of these were present, and he gave them the name "auxi-

*Reprint J. Bd. of Agri., Vol. 24, 1917, p. 11.

†No weighing seems to have been made, but, taking the ordinary specific gravity values, the dressing of humogen in these experiments probably amounted to some 30 to 50 tons per acre.

mones." Further, he stated that the auximone could be isolated by precipitation with phospho-tungstic acid, and he obtained in this way a concentrated stimulant which was said to cause remarkable increases in plant growth.

The purpose of our investigations at Rothamsted was to ascertain whether humogen possesses the value for agriculture which the Kew experiments indicated for horticulture. Claims of the most extensive kind had been made; serious journals had printed statements to the effect that the use of humogen might be expected to "double the food production of the country"; some went a little further and spoke of trebling it.

When, however, the basis of these various statements was examined it was found to be somewhat slender, and to consist mainly of testimonials which, as every agricultural investigator is aware, always seem to be forthcoming whenever a new fertilizer is brought before the public. The trials made at the regular agricultural institutions had in the main given negative results, and there was practically no evidence of agricultural value to which exception could not be taken.

The Woburn pot experiments* with several crops had given increases when the material was used at the rate of 18 or 36 tons per acre; but as the material is offered at £6 or £7 per ton the cost of such dressings would be prohibitive. Outdoor experiments with applications at the rate of 5 cwt. per acre gave only small results.

The Wisley experiments† made out of doors with turnips gave disappointing results which in no sense bore out the claim that humogen contained "50 times as much plant food as farmyard manure"; 1 ton of humogen gave smaller yields than 20 tons of farmyard manure.

Experiments at the Midland Agricultural College also gave negative results.*

More positive results appear to have been obtained at Sparsholt,† but the published data are not sufficient to justify detailed discussion. Seven varieties of potatoes were grown; two, King Edward VII. and Golden Wonder, gave large increases in crop with humogen, while five gave smaller increases of about 20 to 30 per cent.

The basal dressing was 1 cwt. of sulphate of ammonia and 2 cwt. of superphosphate; the amount of humogen added

*Jour. Roy. Agric. Soc., 1915, 76.
†Jour. Roy. Hort. Soc., 1916, 41, 305-326.
*Rept., Midland Agric. and Dairy Coll., 1915, pp. 33-35.
†Report on Potato Expts., Sparsholt, Winchester, 1915.

is not stated; the trial was of "humogen basal dressing" against "basal dressing alone," and no comparison was set up between humogen and farmyard manure.

The results were:

Variety	Unsprayed				Sprayed twice (early and late in July)				Sprayed twice and dressed with "Humogen"			
	tons	cwt.	qr.	lb.	tons	cwt.	qr.	lb.	tons	cwt.	qr.	lb.
*British Queen	4	19	2	11	9	0	3	6	12	12	1	8
King Edward VII	3	16	1	10	4	16	1	20	9	1	2	12
Up-to-date	7	11	3	14	9	17	2	20	11	8	3	20
Arran's Hope	7	9	1	24	8	12	3	2	10	8	3	20
Arran's Chief	5	10	3	16	7	7	0	6	9	0	0	0
Golden Wonder	4	16	1	20	5	8	1	26	10	7	1	8
Langworthy	3	19	0	17	5	4	1	24	5	12	2	0

*The seed was all one-year from Scotland, except that of British Queen, which was direct from Scotland that season.

As the plots were not duplicated it is impossible to say what degree of significance the results possess.

Other experiments at Sparsholt made with tomatoes also led to increased yields; but in experiments with peas, broad beans, dwarf beans, carrots, beets, parsnips, celery, leeks, currants, gooseberries, raspberries, strawberries, apples, pears and plums, none of these "were affected in the least."

A series of tests with tomatoes and cucumbers made at the Lea Valley Experiment Station‡ gave wholly negative results.

The Rothamsted Experiments.

The Rothamsted experiments were undertaken at the request of the Board of Agriculture in 1915. Professor Bottomley gave full information of sources of material, methods, etc., and arranged at a later date for a visit to the Works at Manchester and at Entwistle. Unfortunately the supply of humogen was not available till the end of May, 1916, and the experimental test was therefore less extensive than had been intended. Of four major tests designed, three were carried out satisfactorily, but the fourth with mangolds at Rothamsted was so delayed that it is not desired to attach much significance to it. The results of all the experiments, however, are in agreement.

In order to eliminate local influences of soil, climate, etc., the experiment was carried out partly at Rothamsted, and partly at the Harper Adams Agricultural College under Principal P. H. Foulkes. The experiment was designed to show the effect of humogen by itself, and in conjunction with farmyard manure, and with farmyard manure and artificials; the

‡First Ann. Rept., Expt. and Research Station, Turner's Hill, Cheshunt, 1915.

last being intended to show whether humogen has any stimulating effect that will help the plant to make better use of the foods already supplied.

Two sorts of humogen were used; one coming from Manchester being prepared by the Cleansing Department from peat excavated on Chat Moss, and the other from Entwistle being prepared by the Entwistle Mountain Peat Estate Company, from the peat overlying deposits of limestone.

In all cases the results were negative; the humogen had no effect.

The usual dressing was 10 cwt. per acre, this quantity being suggested by Professor Bottomley as being likely to bring out the value of the humogen.

Harper Adams Agricultural College.

The results with wheat at the Harper Adams College were:—

	Yield per acre. Grain.	Yield per acre. Straw.	Total value of Grain and Straw. £	s.	d.
Humogen, 5 cwt.	46½ bush.	38½ cwt.	26	14	0
No dressing	47¾ bush.	45½ cwt.	28	6	3

If the humogen had any effect at all it was slightly to depress the crop.

Mangolds.

The results with mangolds were:—

Results in Combination With Dung and Artificials.

	With Nitrate. tons.	cwt.	qr.	Without Nitrate. tons.	cwt.	qr.
*Humogen, 5 cwt. per acre	24	15	3	25	18	0
*Humogen, 10 cwt. per acre	27	13	1	28	13	0
†Humogen, 10 cwt. per acre	25	7	0	29	5	0
No humogen	28	0	0	28	1	1

*Entwistle. †Manchester.

Results With Artificials Only. No Dung.

	With Nitrate. tons.	cwt.	qr.	Without Nitrate. tons.	cwt.	qr.
*Humogen, 5 cwt. per acre	22	0	3	....	....	....
*Humogen, 10 cwt. per acre	23	2	3	20	2	0
†Humogen, 10 cwt. per acre	26	11	0	25	18	1
No humogen	22	5	2	23	3	0
Ordinary peat, 5 cwt. per acre	27	5	3	....	....	....
Ordinary peat, 10 cwt. per acre	28	18	2	....	....	....

Results Without Dung or Artificials.

	tons.	cwt.	qr.
*Humogen, 5 cwt. per acre	19	18	1
*Humogen, 10 cwt. per acre	19	15	2
†Humogen, 10 cwt. per acre	18	10	3
No humogen	17	16	2
Ordinary peat, 5 cwt. per acre	19	5	3

*Entwistle. †Manchester.

In one or two cases where there has been no dung the humogen has somewhat increased the crop, notably when 10 cwt. of Manchester humogen were applied with artificials and nitrate; 10 cwt. of untreated peat, however, gave a still larger increase. The untreated peat was from Westmorland and not from Entwistle, but the result does not suggest that bacterisation has effected any very radical change. There seems no reason to assume any very special fertilising action beyond the well-known power possessed by finely divided peat of holding moisture.

Assuming the difference to be real, the 10 cwt. of untreated peat have given an additional 6½ tons of mangolds, while the 10 cwt. of Manchester bacterized peat have given 4¼ tons. On the other hand, the Entwistle bacterized peat has given only 17 cwt. additional crop, a quantity to which no significance can be attached as it lies within the error of experiment. If the result means anything, it is that there is no more difference between the two samples of humogen than between humogen and untreated peat.

Garden Crops.

A further series of experiments was made on a smaller scale with garden crops. Only in the case of peas and potatoes was any increase obtained as a result of using humogen; the other crops, beans and cauliflowers, were actually depressed. Taking the results as a whole and allowing for the rather large error inseparable from garden crops, one may conclude that they show no increase as the result of applying humogen.

	Peas. lb.	Beans. lb.	Cauliflower. lb.	Potatoes. lb.	Total lb.
Humogen, 1 ton per acre	29½	21½	20	24	95
Humogen, 2 tons per acre	33	19	26	18	96
Humogen, 1 ton per acre and complete artificials	36	17½	19	14	86½
Ordinary peat	28	28	26½	20	102½
No dressing	27	24	33	15	99

Rothamsted Experimental Station—Mangolds.

Owing to the circumstance that the humogen was not delivered till the end of May, the Rothamsted experiments with mangolds are not so satisfactory as those at the Harper Adams College. The lateness of sowing caused the plants to be badly affected by drought; plants on the humogen plots suffered at least as much as the rest. The results of the experiment are:—

	Plot.	No. of Plants in Plot. (1-10 acre.)	Yield per acre. Tons.
No manure	6	651	4.0
Manchester humogen only	1	518	2.8
Entwistle humogen only	11	603	3.5
Artificials only	7	899	5.4
Manchester humogen+artificials	2	793	4.9
Entwistle humogen + artificials	12	813	6.5
Dung and artificials only	10	926	9.6
Manchester humogen + dung and artificials	5	766	8.5
Entwistle humogen + dung and artificials	15	1,200	13.4

None of these crops is good, the drought having depressed them all considerably.

In one place the humogen appears to have had a good effect, but there is evidence that this is not real. Adjoining Plots 10 and 15 were two others (Plots 17 and 16) receiving complete manure, but no humogen; though treated exactly alike their yields were 11.2 and 16.5 tons, respectively, i. e., the two plots were under identical treatment, and yet gave exactly the same differences as the two plots, one of which received humogen while the other did not. It is therefore not permissible to attribute the difference in yield to the humogen, but rather to a local difference between Plots 10 and 17 on the one hand, and Plots 15 and 16 on the other. Such local differences come out very strongly in periods of drought, and for that reason late experiments rarely give satisfactory results.

Thus the field experiments are uniformly negative. They show no special fertilizing effect, and in the only cases where increases were produced they were no better than were obtained from untreated peat.

Mustard in Pots.

The pot experiments at Rothamsted were carried out under much more favorable conditions than the field experiments described above; only a small amount of humogen was

wanted, and this was obtained in time. The general plan was to apply the humogen at the rate of 10 cwt. per acre, and to give it also in conjunction with a basal dressing containing potash and phosphates. Half of the controls received nitrate of soda containing nitrogen equal to that in the humogen. The crop sown was mustard, and growth was satisfactory throughout.

Again, however, the results were entirely negative and the humogen was without effect; untreated peat had at least as good an action. The figures are as follows:

Dry Matter Formed Per Pot—Average of Six Pots.*
Mustard.

	Series	No. Basal Dressing	With Basal Dressing = 10 gm. Superphosphate and 5 gm. Sulphate of Potash per Pot	
		gm.	gm.	
No humogen	1	12.86	15.91	
Entwistle humogen	2	13.015	16.86	5 gm. humogen per pot.
Manchester humogen	3	13.00	17.59	5 gm. humogen per pot.
Hambledon peat	4	13.34	17.20	5 gm. humogen per pot.
Cheshire peat	5	12.47	17.04	5 gm. humogen per pot.
Sodium nitrate	6	.....	16.36	.08 gm. per pot : equiv. N. to that in 5 gm. Entwistle peat.
Fish guano	7	.....	16.50	.31 gm. per pot.

*The humogen was added at the rate of 10 cwt. per acre, or 0.05 per cent of the weight of soil in the pots. As an equivalent dressing in Series 6 nitrate of soda was added at the rate of 0.16 cwt., *i. e.*, 18 lbs. per acre or 0.008 per cent by weight of the soil in the pots. The weight of soil per pot was 10 kilog. and the basal dressing was 10 gm. superphosphate + 5 gm. sulphate of potash, these being found by experience to be suitable. The fish guano contained nitrogen equivalent to that in the Entwistle peat.

Barley in Water-Culture.

The last series of experiments was carried out by Dr. Winifred Brenchley. Professor Bottomley had obtained a 50 per cent increase in growth of wheat in water-culture by adding some of the extract of bacterized peat. Dr. Brenchley's experiments were made with barley because this plant has certain advantages over wheat for water-cultures; the results are given in the table following.

The plants receiving humogen were rather darker in color than the others, but the difference in weight is less than 5 per cent, and no significance can be attached to this result.

Peas gave equally negative results.

This is in direct disagreement with Professor Bottomley's result, but it is not difficult to account for the discrepancy.

Professor Bottomley's curve looks very convincing, but the figures are less satisfactory. The average weight of his individual plants was about 0.2 gm. fresh weight, while that of Dr. Brenchley's plant was 11.4 gm. dry matter. It is quite evident that there was something wrong with his cultures, for neither the untreated plants nor those treated with humo-

gen made normal growth; indeed, his control plants actually lost weight. The light and atmospheric conditions at King's College are probably not very good, and are certainly not so good as at Rothamsted, so that, even assuming equal skill and attention, the plants would hardly have done as well as in our laboratories. In view of the very abnormal growth at King's College the writer does not consider that there is any evidence of stimulation of growth.

Water-Cultures—Average 10 Plants—Barley.

	Weight of Dry Matter per Plant		
	Shoot	Root	Total
	gm.	gm.	gm.
No humogen (control)	9.35	1.76	11.1
Extract of .2 gm. of humogen per plant	9.75	1.74	11.49
Extract of .6 gm. of humogen per plant	10.08	1.57	11.65

Summary.

Summing up the results, we find no evidence that humogen possesses any special agricultural value. There is not the least indication that it is "50 times as effective as farmyard manure," to quote an often repeated statement, and there is nothing to show that it is any better than any other organic manure with the same content of nitrogen. It is offered at present at £5 per ton in two-ton lots; our experiments give no reason for supposing that it is worth anything like so much.

This result is in entire disagreement with the claims made on behalf of humogen, and the question naturally arises: Are those claims wholly without foundation?

In endeavoring to arrive at a solution of this question two circumstances must be taken into consideration: (1) the fact that good results were undoubtedly obtained in pot experiments both at Kew and at Wisley; and (2) the evident variability in the composition of humogen.

(1) The writer is quite prepared to believe that the horticulturists found humogen in the quantities used at Kew and at Wisley a valuable addition to the compost used for potting up plants, but he is not prepared to say that humogen is any better than an equal amount of untreated peat in an equally fine state of division. Such finely-divided organic matter will serve several useful purposes in pots, and when it forms 12 per cent or more of the whole bulk it is present in sufficient amount to exert a useful effect.

It is quite possible that heavy dressings would have good effects on poor soils deficient in organic matter, but they would have to be on a far larger scale than is possible at present prices.

(2) The second point to which attention should be directed is the evident variability of the samples. The

analysis published in "The Spirit of the Soil," by G. D. Knox (p. 86), for which Professor Bottomley accepts responsibility, claims:—

Percentage of total nitrogen in humogen.....4.310 per cent.

Rothamsted analyses on the other hand show:—

	As sent out.	In dry matter.
Percentage of total nitrogen in Manchester humogen	0.570	1.29
Percentage of total nitrogen in Entwistle humogen	0.431	1.32

Here, of course, is an enormous discrepancy. The book seems to indicate that the 4.3 per cent of nitrogen is contained in humogen as sent out, but even if this is presumed to be an error, and the figure is taken to represent the amount in the dry matter, it is still greatly in excess of anything that we find. It must be supposed either that there has been an error in Professor Bottomley's analyses or that the two samples of humogen sent to Rothamsted were considerably poorer than the earlier samples.

Dr. Voelcker has also called attention to the variations in samples sent out, one examined by him containing 0.48 per cent of soluble nitrogen, while another contained 0.08 per cent only.

This variability is, of course, highly unfortunate. It is possible that some samples have acted well in the field; it is certain that others have not. There is no definite evidence that "bacterization" really adds to the value of peat. In the writer's view the wisest plan would be to concentrate on experimental work and stop all propagandist operations until some definite basis of incontrovertible fact has been attained. The latter point is still a long way off; the problem of utilizing peat is sufficiently difficult to occupy the whole attention of a laboratory for some years, and nothing but quiet, serious work is likely to solve it.

The editor of the Journal of the Board of Agriculture has made the following addenda to Dr. Russell's article: A proof of the report of these experiments by Dr. Russell was sent to Professor Bottomley, who writes as follows:

"The results obtained last year by Dr. Russell are not surprising in view of the fact that late last autumn I discovered that the material sent to Dr. Russell, both from Entwistle and Manchester, was not bacterial peat but a chemically treated peat, which contained substances injurious to

plant growth. Most unfortunately there was a serious error in the manufacture of the early lots of humogen sent out from both places. Briefly, what happened was as follows: At both places work was not commenced until late in March; the machinery available was most inadequate, and the wet peat, as cut from the bog, had to be used at once, without any preliminary aeration or drying.

"In the process of manufacture a small amount of sodium carbonate (½ to 1 per cent) is mixed with the raw peat, sufficient to neutralize the acidity without producing a soluble humate, before incubating with the aerobic decomposition organisms. In the original manufacture of humogen at Greenford, the depth of color of the water extract obtained after incubation with these organisms was used as a guide to the effectiveness of the bacterial decomposition of the peat, and incubation was allowed to continue until a dark colored extract was obtained.

"As humogen was wanted as quickly as possible last spring for experimental work in order not to miss the season, it appears that those in charge of the works, well knowing the solvent action of alkalies on peat humus, added an excess of sodium carbonate to the raw peat—in some cases as much as 6 per cent—in order to obtain quickly a soluble humus, and thus, as believed, obviate the necessity for a lengthy period of incubation. This was contrary to my definite instructions as to quantities and time for incubation. The result was that a chemically-treated peat, containing an excess of soda, was sent out instead of a properly bacterized peat.

"I had no suspicion that anything was wrong with the early lots sent out until I heard from Messrs. Sutton, of Reading, that their experiments with the material were showing that it contained something which actually checked plant growth, and as this was contrary to what they had anticipated, after seeing the results obtained at Kew Gardens in previous years, they wanted to know the reason. For some time I could obtain no clue, for each time I visited the works everything appeared to be in accordance with my directions, and it was not until September that I was able to locate definitely the cause of the trouble.

"It was impossible, owing to my college duties in London, for me to be present at Entwistle and Manchester when the first lots were being manufactured; hence I had to depend on other people for my instructions being carried out.

"Although the error was beyond my control, I deeply regret that the time and labor involved in the Rothamsted

experiments should have been expended on testing a substance which was not humogen.

"That the material sent to Rothamsted was not properly prepared is evident from the negative results obtained by Miss Brenchley with water cultures. In every other case of water culture experiments with properly bacterized peat, including those carried out under the supervision of Professor V. H. Blackman at the Imperial College of Science, South Kensington, and which were seen by representatives of your Board, water extracts of bacterized peat have given remarkable results. These results will be published by the Royal Society, and a resume of them will be given in a later issue of this Journal."

Dr. Russell states that the material was sent to him in May, 1916, as true humogen; it was not purchased unknown to the vendors; and Professor Bottomley, the Cleansing Department of the Manchester Corporation, and the Entwistle firm, all knew that it was for the purpose of these trials. Neither then, nor in any subsequent correspondence, nor on the occasion of Dr. Russell's visit to the works at the end of August was there any hint that the material was defective and the first intimation to this effect was a letter from Professor Bottomley to Dr. Russell on March 17th, after proofs of the present report had been submitted to Professor Bottomley.

BACTERIZED PEAT.

Prof. W. B. Bottomley, of King's College, lecturing on Monday evening, January 29, 1917, on "Plant Foods and Soil Problems," said that proper plant feeding was the one essential to successful crop production, whether they exploited certain crops or the more special kinds, such as cotton, rubber, or tea. The more suitable the plant food in the soil the better would be the fertility. He said he had obtained some remarkable results from the application of specially treated extract of peat to certain plants. He pointed out that there was a new and constant supply of plant fertilizer owing to bacterial action on the soil, and that it was not sufficient to supply phosphate, potash, or nitrates to the soil. There must be organic matter. They could not grow their crops properly unless there was organic matter in the soil. Where were they to get it? There were millions of tons of waste peat bogs which could be converted into substances far more valuable and effective than the best animal fertilizer they could obtain. Instead of talking of exploiting plants, they should be talking

about the exploitation of peat bogs. They must manage to grow more plants in a given area, must grow better plants, and grow them at a cheaper cost.

(Chem. Trade Jour., vol 60, 1917, page 94.)

PEAT—TREATMENT OF—FOR MANURIAL AND OTHER PURPOSES.

(W. B. Bottomley, Br. Pat. 16,658.) In the aerobic treatment of peat previously described, the resulting fertilizer owes its efficacy to the presence of auximones, and not directly to that of ammonium humates. The initial neutralization of the peat is much accelerated by sprinkling it in a 6-inch layer with sodium carbonate, in amount equal to about 3 per cent of the weight of anhydrous peat, dissolved in about five times its weight of water. Further acceleration is effected by breaking down the cellular tissue with live steam about 60 pounds pressure in a tank containing perforated steam pipes and covered loosely. This action takes about 30 minutes per ton of peat. After the material has been spread on a heated floor in a 1-foot layer, water containing ammonifying and nitrifying organisms is sprinkled over it, and then the product is maintained at 26° to 28°C for about three days.

Bacterized Peat.

The results of experiments carried out on bacterized peat supplied by Professor Bottomley were submitted by Dr. Tocher to a meeting of the Governors of the College of Agriculture held at Aberdeen on Thursday, February 22. Dr. Tocher stated that the results could be regarded as only of a preliminary character. The claims made on behalf of the substance had not been established. It was found that the yield from common peat plots was just as good as the yield from bacterized peat plots.

(Chem. Trade Jour., vol. 60, 1917, page 168.)

INFLUENCE OF CROP, SEASON AND WATER ON THE BACTERIAL ACTIVITIES OF THE SOIL.

(J. E. Greaves, R. Stewart, and C. T. Hurst, Jour. Agri. Res., vol 9, 1917, p. 293). The quantity of nitric nitrogen in the surface 6 feet of alfalfa soil is comparatively low throughout the season, but is higher in the fall than in the spring or summer. The quantity present decreases as the water applied increases; yet the quantity formed in the soil

increases as the water applied increases, but is greatest per acre-inch of water when only 15 inches of water is applied.

The quantity of nitric nitrogen in the surface 6 feet of potato, oats, corn, and fallow soil decreases as the water applied increases; but the quantity formed for each of the cropped soils is greatest where the largest quantity of water was applied. The quantity formed per acre-inch of water applied is greatest where only 15 inches of water was applied.

Large quantities of nitric nitrogen disappeared from the fallow soil during the summer months. This is attributed to the growth of bacteria, which transforms it into protein substances and not to denitrification.

The larger applications of irrigation, 37.5 and 25 inches of water, carry much of the nitric nitrogen beyond the sphere of action of the plant, and this accounts for the decrease in crop yield, which is often noted when excessive quantities of irrigation waters are applied to a soil.

The application of water to a soil depresses the number of organisms which will develop upon synthetic agar in alfalfa, oats, and potato soil, but increases them in fallow. The results obtained with the corn are irregular.

Ammonifying powers of all the soil, except the alfalfa, was increased by the application of irrigation water.

Water increased the nitrifying powers of all the soils except the oat soil.

There was a difference of 2° Fahrenheit in the temperature of the soil of irrigated and unirrigated in favor of the unirrigated. This difference in temperature was perceptible to a depth of 4 feet.

The number of organisms was higher in the cropped than in the fallow plots, and this is probably due to the plant residues left upon the cropped soil.

Naming the soils in the order of increasing ammonifying powers, we have alfalfa, oats, corn, potato and fallow. By naming them in the order of increasing nitrifying powers, they are, fallow, corn, oats, alfalfa and potato.

The alfalfa not only feeds closer upon the nitric nitrogen of the soil than do other crops but it also increases the nitrifying powers of the soil. Hence, it would deplete the soil of its nitrogen more rapidly where the entire crop is removed than would other crops.

The use of irrigation water increases the bacterial activities of the soil, which render soluble the nitrogen, and where excessive quantities of water are used considerable of this is washed from the soil, thus unnecessarily depleting the soil of its nitrogen. This in turn gives diminished yields on the soil.

Effects of Bacterized Peat

A paper entitled, "Some Effects of Growth-Promoting Substances (Auximones) on the Soil Organisms Concerned in the Nitrogen Cycle," by Florence A. Mockeridge, was communicated by Prof. F. W. Oliver at a meeting of the Royal Society last week. Peat which has been further decomposed by the action of certain aerobic soil organisms under suitable conditions (bacterized peat) contains plant growth-promoting substances (auximones). The investigation deals with the effect of bacterized peat and the various auximone fractions obtained from it upon the four chief groups of soil bacteria concerned in the nitrogen cycle, in situ and in liquid culture.

The addition of bacterized peat to soil, said the author, increased the rate of nitrogen fixation quite independently of any bacteria contained in the material. This increase was not due to aeration, nor could it be brought about by chemically-treated peat. Experiments in liquid culture showed that a water extract of this material greatly increased the nitrogen fixation of Azotobacter and of Bacillus radicola. An alcoholic extract and the decomposed phosphotungstic acid and silver-baryta fractions from it were also very effective. Similar results could not be obtained with chemically prepared soluble humus or with artificial humus.

The accumulation of nitrate in soil containing bacterized peat was greater than that which could be accounted for by the soluble nitrogen which it contained, and took place more rapidly than in a similar soil provided with an equal amount of soluble nitrogen as ammonium sulphate. As the water extract of the material was found to be directly nitrifiable, its effect upon the rate of nitrification was not tested, but the auximone fractions, which were not nitrifiable, greatly increased the rate of nitrification of ammonium sulphate solutions. The auximone fractions were without effect upon the rate of ammonification in soils and upon the ammoniacal fermentation of urea. The water extract had no effect upon the rate of denitrification, but the auximone fractions directly inhibited the process. The work indicates that certain decomposition products of organic matter stimulate the activities of certain soil bacteria, and appear to play an important part in nitrogen metabolism.

(Chem. Trade Jour., vol. 60, 1917.)

CLOTHING FROM PEAT.

Interest is being manifested by American manufacturers in a report regarding the economic utilization of peat fiber for clothing. An article referring to the new process appeared in "Textile Mercury," Manchester, England, from which it has been reprinted in the daily report of the U. S. Bureau of Foreign and Domestic Commerce as follows:

"A process is stated to have been perfected in Sweden for the manufacture of a strong textile material from peat fiber. The inventor, an engineer named Jegeaus, began to study this process 20 years ago, but was hampered by the fact that the manufacture was much too costly, so that he was unable to turn his ideas to any practical use. Induced by war conditions, however, he resumed his experiments, and has now succeeded in making dress materials from peat on a large scale.

The prices of these fabrics are said to be somewhat lower than those for artificial wool, and the durability great. The inventor himself and several other persons are already wearing "peat" clothing, and a factory for the working of the process is about to be erected."

A further consular report on peat fiber makes the following statement: The manufacture of spinning material out of peat fiber has been attempted here, and the experiments have advanced so far that cloth as well as clothing has been made out of peat fiber mixed with other textile materials. This is not likely, however, to lead to any important industry; but absorptive material has been produced from white sphagnum moss and wood pulp. The price of chemically-cleaned cotton is now about 3.2 crowns per kilo ($0.389 per pound), about three times the price before the war. Prepared sphagnum moss can absorb 22 times its own weight in moisture; cotton, only 10.

EXPERIENCES IN OHIO MUCK FARMING.*

(By Ralph W. Jordan.)

To be a member of this society is of much profit to me. I hope that I may be of service to it. To be called upon to read a paper is an honor. It is my hope that the experiences, ideas, and ideals of muck farming as noted in this paper may be of help and encouragement to those engaged in a like work.

The development of swamp lands is coming as one of the last developments of land in our country. The next twenty-

five years will witness more being done in this direction than the previous one hundred years in the history of our nation. The example of the tracts of muck developed in the past fifty years, modern machinery, and capital will make this possible. Great opportunities await enterprise in the development of our muck lands for agricultural purposes. Capital and labor can be more profitably utilized in the future than in the past upon this work. In fact no other opportunity in the intensive development of the soil in a large way will equal muck farming.

In several ways muck farming differs from other types of farming. A muck soil is naturally the most fertile soil in existance. This in itself makes the soil desirable for intensive crops. However, other advantages must accompany fertility in order to render it economically possible to develop our muck lands. In the very first place there must be adequate drainage. In this connection I have reference to adequate outlet for the surplus water of the territory rather than a system of underdrains. Muck lands because of the very fact that they were deposited where drainage was poor is proof sufficient that we must have ample drainage if we use the muck for agriculture. Not a few growers from time to time loose their entire crops by inundation of the land. In our present stage of progress this problem is being cared for by individual effort. In places a few of the growers have diked their land, and pump the surplus water over the dikes as occasion may require. This only aggravates the problem for the grower without dikes and pumping plant. Concerted action would be highly profitable. In fact the difficulty will not be overcome except by unity of effort in the district so affected.

Location is important in rendering muck farming highly profitable. Because of the weight of the products grown on muck land, a good market outlet must be had. In some places the growers haul as much as six or seven miles. But the best locations are within three miles of a shipping point. One peculiar fact about our muck lands is the intrinsic value of a large area. Muck land is brought to its highest state of cultivation where there is sufficient acreage to develop a district. There is something inherently valuable about a group of individuals all working at the same problem. The inspiration and encouragement by contact and example will lead hundreds of people to do exactly the same thing as the most aggressive and courageous of the community.

Because of the intensity of operations on muck land, small acreage have been found most profitable to farm. The

managerial ability of the very best growers is reached in looking after the details of fifty acres of real intensive farming. Some of the very best cared for muck farms producing the highest profit per acre have 15 to 25 acres. Individuals make good profits on 5 acres. The past is strewn with wrecks of those who would attempt too much on muck. I mention this in passing because many men who see a few acres under successful operation at once begin to figure upon multiplying profits by multiplying acres. Without some plan that will appeal to the self-interest of the men who perform the labor, the profits per acre will fall away very rapidly as the acreage increases.

In the State of Ohio, onions and celery are the chief crops. The onions are sown in the early spring and harvested in the fall. The entire crop, except the preparation of the land, is cared for by hand work and hand tools. In some places the topping is performed by machinery. Where tractors are used in preparing the land the horse is entirely eliminated from the crop. Ohio as an onion growing state, ranks second in the North Commercial Onion belt. The crop yield for the state will average 325 bushels per acre. The yield on the best cared for fields will run 500 bushels per acre in normal years. The crop is standard and reliable for muck ground. In some districts the people depend entirely upon the success of the onion crop for their means of support. In the great Hardin County section more than 4,000 acres are grown annually. In Wayne and Medina Counties one company, the largest single onion growers in the world, operate on an average of 700 acres annually. The acreage is divided into several farms. Even then we may consider the operations of this company as a most remarkable exception to the rule of size of acreage to handle.

In some districts it has become the custom to grow celery almost to the exclusion of onions. The same as with onions there are places where the growers are dependent for their income upon the success of the celery crop. Celery requires more detailed attention than does the onion crop. The crop ranks second only to onions and is a standard crop for muck land. Celery is planted at intervals so as to harvest the crop in succession. A considerable part of the celery is washed and shipped in express lots from the first of July until Thanksgiving. As grown in Ohio celery requires horse work. The tractor will not supplant the horse in cultivating.

The celery-onion rotation works out well in Ohio. In places, however, either of these crops is supplemented with cabbage, carrots or potatoes for a rotation. Lettuce is not

grown extensively as in New York State. Nor is peppermint grown extensively as in Michigan and Indiana.

I am most happy to say that progress is being made in the growing and handling of muck crops in Ohio. Overhead irrigation is coming into use. Specially made paper is replacing lumber for blanching celery. More interest is being taken in good onion seed and more pride in the growing and grading of marketable onions. The standard 100-pound bag for onions has come into use the past three years. The bag in many cases replaces the old method of marketing the crop in bulk in cars.

During the present year a celery-shipping association has been organized in the great Chicago Junction celery district. The Ohio Vegetable Growers' Association is devoting a goodly part of their annual meeting program to the muck interests. The National Onion Association, organized for the purpose of collecting and disseminating information among its members, originated in Ohio.

With the improvement of material things a new spirit of aggressiveness is taking hold of many of the muck growers of Ohio. During the past few years many new men have come into the field devoting their money and thought towards this work. This infusion of new life into the enterprise is in only the first stage of progress. We may safely predict that Ohio will continue to be in the front ranks in the agricultural development of her muck soils.

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*Read at the Washington meeting, Sept. 22, 1916.

Peat and Its Utilization*

By R. O. WYNNE-ROBERTS

It is somewhat remarkable that whilst Canada has experienced considerable difficulty in obtaining coal from the United States, we have great deposits of peat waiting to be utilized. This anomalous situation is doubtless due to our intimate acquaintance with coal and to the absence of practical experience with peat. Peat is used as domestic fuel and for the generation of power on a large scale in Russia and in a smaller measure in Norway, Denmark, Germany, Italy, Ireland and other countries. As stated by Mr. B. F. Haanel, B. Sc., whose report on "Peat, Lignite and Coal," published in 1914, will be freely quoted, "The problem which confronts Canada is not conservation, but the best means of rendering available the various supplies of low-grade fuels. The great coal measures of Canada are situated in the extreme east and west; but, lying between these points is a vast territory devoid of coal measures, which is, at the present time, dependent on some foreign source for a fuel supply. In one sense conservation is being practiced to a very high degree, because, in certain parts of the country, practically all the coal required for industrial and domestic purposes is being imported from the United States, while valuable fuel deposits are lying practically intact. But this kind of conservation never leads to commercial or industrial prosperity, and cannot, therefore, be recommended."

Many of the peat bogs, which are peculiarly adapted for manufacture into fuel for domestic and power purposes, are conveniently situated as regards transportation facilities and contiguous industrial communities.

The peat bogs which have been investigated in Ontario are estimated to produce, roughly, about 65 million tons, with 25 per cent moisture; Quebec, about 40 million tons; Manitoba, about 2 million tons. The lignite beds of the Prairie Provinces, according to Mr. D. B. Dawling, are capable of yielding about 100 million tons for one thousand years, but at present the quantity mined is insignificant compared with the immense deposits that are available. The economic results of importing coal and exporting our money need not be discussed here, but it is evident that if our peat and lignite fuels were

*The Canadian Engineer, Mar. 8, 1917, vol. 32, pp. 216-218.

utilized in a scientific manner and on an adequate scale much anxiety, discomfort and loss due to the severity of the weather and the difficulty of obtaining imported coal would have been minimized.

Each class of fuel must, of course, be used in a particular manner if the best results are to be secured, and peat requires special attention, because in its natural condition it contains approximately 90 per cent of water. When the bog is thoroughly drained the moisture content may be reduced to 88 per cent. Mixing with dry peat or hay and pressing, the percentage of water can be reduced to 70 to 75 per cent, two pressings to 53 per cent, and by subsequent drying to 25 or 30 per cent. The degree to which peat has been humified has a considerable effect on the facility of extracting the water. Peat of recent deposit is more fibrous than the older beds, and water can be pressed out readily, but when humification has been carried to great extent hydrocellulose or gelatinous substance is present, and this absorbs water and increases in bulk until it has the consistency of soft soap. Well-humified peat, which has been thoroughly pulped and repulped, has the appearance, when dry, of a high-class lignite. It has a very fine texture, is hard and dense, and offers considerable resistance to breaking. The separation of the water from the peat has occupied the attention of many, and the data that is available is interesting information to those who are associated with the question of sewage sludge disposal, because the difficulties encountered are much alike.

Owing to the fact that peat is a low-grade fuel, which must be manufactured and sold at a comparatively low cost if it is desired that it should serve as a substitute for coal, or even when it is used in gas producers, the process of excavation, pulping, drying, and so on, must be arranged in such a way that the cost of labor and power is kept as low as possible. If peat can be manufactured successfully in Russia, Germany, Norway and Denmark, where the climatic conditions are not so favorable as those obtaining in Canada, it is within reason to assume that an even greater degree of success could be realized in this country.

The most promising way of utilizing peat is by gasification in gas producers and the recovery of the nitrogen. The total quantity of gas having a calorific value of about 140 B. t. u. per cubic foot is estimated at 90,000 cubic feet per ton of 2,000 lbs. of absolutely dry peat, or, say, 67,500 cubic feet from peat containing 25 per cent of moisture. If 12,000 B. t. u. are allowed per b. h. p. hour, each ton of moist peat will give approximately 787.5 b. h. p. hours, of which about

75 per cent will be available for power, that is, 590. b.h.p. hours. As already stated, there are about 65,000,000 tons of peat in Ontario, and the potential power of this fuel if utilized in this manner will be, roughly, 4,570,000 brake horsepower years, which would furnish 45,700 horsepower for 350 days per year for 100 years, so that Ontario has a valuable source and asset which is waiting to be utilized. But this is not all. The average percentage of nitrogen content in the peat beds which have been investigated is about two—it ranges from 1.26 to 2.77 per cent. If the efficiency of ammonia recovery process is assumed to be 70 per cent, the quantity of sulphate of ammonia from 2 per cent nitrogen content will be about 100 pounds per ton of peat containing 25 per cent moisture; consequently, the Ontario peat bogs are capable of yielding, through the agency of recovery gas producers, about 6,500 million pounds, or 3.35 million tons, of sulphate of ammonia. Spreading this over 100 years equals 32,500 tons per annum. This sells at present at about $70 per ton, but we will suppose, for the purpose of arriving at a conservative estimate, $60 per ton. Furthermore, let the value of energy be placed at $12 per b.h.p. per annum. Ontario alone possesses a potential gross annual income of:—

Gas power, 45,700 h.p. at $12	$ 548,400
Sulphate ammonia, 32,500 tons at $60	1,950,000
	$2,498,400

It will, of course, be necessary to pay for the cost of producing the power and sulphate, but it is not pertinent to the object of this article, which is to show that Ontario has a valuable asset in the peat beds, and what applies to Ontario is applicable to the other provinces. Saskatchewan, Manitoba and Alberta have vast areas of lignite which can be utilized, and these also constitute a most valuable natural resource that awaits utilization.

The gas may be used for many purposes—for driving gas engines, raising steam, industrial processes, domestic heating, etc. As Ontario has a comprehensive hydroelectric system, it is manifest that peat can be used for the development of power only where hydroelectricity is not available at equal cost, but the production of gas will, doubtless, be utilized for other purposes. With regard to ammonium sulphate, it may be stated that it is used in immense quantities as fertilizer, and the bulk of it is derived as a by-product of the destructive distillation of coal. Dr. Lunge, in his fifth edition of "Coal Tar and Ammonia," states that "Synthetical production of

ammonia from atmospheric nitrogen must find its limits in the impossibility of producing the requisite enormous amount of electrical energy, whether by water power or otherwise. The principle source of ammonia will be always the nitrogen of coal," which will include peat and lignite. In 1915 Canada imported $1,087,000 worth of fertilizers of different classes, and, as the soil is reduced in fertility, due to gradual exhaustion, more fertilizers will be necessary. Peat and lignite, therefore, afford excellent local sources for the supply of ammonium sulphate. The following table will show what results are obtained by the use of this class of fertilizer:—

Country.	Sulphate of Ammonia per Acre.	Total Crops Raised per Acre			
		Wheat.	Barley.	Oats.	Potatoes.
	Lbs.	Lbs.	Lbs.	Lbs.	Tons.
Belgium	17.83	2,228	1,908	2,572	6.58
Germany	9.98	2,012	1,400	1,586	5.25
England	5.35	1,756	.....	1,591	5.05
France	2.23	1,238	908	1,154	3.18
United States	1.34	.....	.....	.....	.....

Sulphate of ammonia is especially valuable for the cultivation of beet-root. Its action is slower than that of nitrate of soda, but for that reason it is all the more lasting. It is absorbed by the soil and retained even after heavy rainfalls, whereas nitrate of soda is stated to be washed out. Sulphate of ammonia serves for preparing other ammonium salts, sometimes for liquor ammonia, for making ammonia-alum. A 10 per cent solution of sulphate of ammonia is employed to render tissues, papers, etc., noninflammable.

There are several gas-producers which give excellent results. The Mond type has been used in connection with peat in Italy and Germany. The Lymn producer is now taking a prominent position and is highly spoken of.

According to Mr. Haanel, it would be unprofitable to utilize peat for producer gas and the recovery of the ammonia unless the quantity of nitrogen is at least 1.5 per cent of the dry sample. Fortunately, there are several peat bogs which have been investigated having a higher nitrogen content than 1.5 per cent.

In closing this article the Holland peat bog may be referred to. It is only 42 miles from Toronto, and has an area of about 5,000 acres. The quantity of peat fuel containing 25 per cent moisture is estimated at 8,218,000 tons, and the nitrogen content is about 2.67 per cent. based on dry sample, or about 2 per cent. based on 25 per cent moisture standard. The

calorific value of this peat (dried) is about 8,510 B. t. u. per pound. Mr. Haanel estimated the total yield of ammonium sulphate at about 507,500 tons, and, assuming 120 tons of theoretically dry peat were consumed per 24 hours, the bog would last for about 147 years. The power gas available would be sufficient to develop about 4,000 h. p. continuously for the above period.

Peat is also used as litter, possessing antiseptic properties and a capacity for absorbing nitrogenous organic matter. It is used in Germany in connection with sewage from pail closets, also for packing fruit, vegetables, etc. It may be used for insulating icehouses and steam pipes. Prof. Bottomley has succeeded in bacterizing peat, in which form it is found to be an excellent fertilizer, whilst the French make paper and cardboard from peat which has undergone but slight decomposition.

PEAT IN KANKAKEE COUNTY (ILLINOIS).

Soil Report No. 13 of the Illinois Agricultural Experimental Station, in the investigation of KANKAKEE COUNTY SOILS, under the direction of Cyril G. Hopkins, J. G. Mosier, E. van Alstine and F. W. Garrett, has recently been issued. There is considerable acreage of peat in this county, and below is an extract of the report of the tests of this soil.

Kankakee county is on the eastern line of the state, 125 miles south of the northern boundary. It has been covered completely by two glaciations, or ice sheets, the Illinoisan and the early Wisconsin.

Although the county is traversed by two of the large rivers of the state, the Kankakee and the Iroquois, it presents no great variations in topography. The greatest differences may be seen in the western, or northwestern, part of the county as the result of erosion by the Kankakee river. The county may be divided roughly into three regions—that of the early Wisconsin glaciation, the southwestern part; that of the late Wisconsin glaciation, the northeastern part; and the former lake, or swamp, region. These divisions are more physiographic than topographic, and are subsequently considered more fully. Outside the swamp area the topography is largely morainal, having been produced by the glaciers, but it is not of an extreme type. Dune topography prevails in some parts of the lake, or swamp, area.

The large area of the swamp between the glacial regions consists of soils that have been derived from lake deposits or largely modified by the lake and the currents which flowed

through it. Large quantities of the finer glacial material have been washed away from this region, leaving the coarser material, which in some places is still exposed. Bowlders are common over some parts, so much so that cultivation is difficult, and in a few small areas impossible until the bowlders are removed. In the western part of the county, these bowlders and pebbles have been covered with fine material to a depth of 16 inches to several feet.

The soils of Kankakee County are divided into the following four classes:

(a) Upland prairie soils, rich in organic matter. These were covered originally with prairie grasses, the partly decayed roots of which have been the source of the organic matter.

(b) Upland timber soils, including a large part of the land that was formerly covered with forests.

(c) Terrace soils, or, more properly, those soils which occupy the gravel and sand outwash plain produced by the old lake.

(d) Late swamp and bottom-land soils, which include the overflow lands or flood plains of streams and the very poorly drained lowlands where peats, peaty loams, and mucks have been formed.

(e) Miscellaneous.

Table 1 following shows the area of Late Swamp and Bottom-land Soils in Kankakee County in square miles and in acres, and its percentage of the total area. Tables 2, 3 and 4 present other data, as indicated.

Table 1.—Area of late swamp and bottom-land soils in Kankakee County.

Name of Type	Area in square miles	Area in acres	Percent of total area
Deep peat	2.73	1,748	.41
Medium peat on clay	1.06	678	.16
Medium peat on sand	1.71	1,094	.26
Peaty loam on sand	6.15	3,936	.92
Peaty loam on rock	1.39	890	.21
Mixed loam	3.84	2,457	.58
Clayey muck	.14	90	.002

Table 2.—Average pounds per acre in 2 million pounds of surface soil (about 0 to 6⅔ inches).

Soil Type	Total Organic Carbon	Total Nitrogen	Total Phosphorus	Total Potassium	Total Magnesium	Total Calcium	Limestone present	Soil acidity present
*Deep peat	291,030	26,710	1,460	6,830	3,770	24,430	Often	Often
*Medium peat on clay	216,900	19,970	1,570	10,060	5,230	17,750	.....	190
*Medium peat on sand	221,970	18,810	750	9,870	2,430	20,170	4.420	.....
Peaty loam on sand	94,670	8,670	1,330	20,770	4,930	19,840	Seldom	Often
Peaty loam on rock	134,400	11,120	1,760	19,820	6,860	17,280	.....	20
Mixed loam	112,600	9,020	1,560	42,220	13,200	17,340	11,420	.....
Clayey muck	262,660	27,900	2,080	32,700	12,600	25,540	.....	20

*Amounts reported are from 1 million pounds of deep peat and medium peat.

Table 3.—Average pounds per acre in 4 million pounds of subsurface soil (about 6⅔ to 20 inches).

Soil Type	Total Organic Carbon	Total Nitrogen	Total Phosphorus	Total Potassium	Total Magnesium	Total Calcium	Limestone present	Soil acidity present
*Deep peat	408,780	35,340	1,750	19,260	6,120	32,140	.....	220
*Medium peat on clay	267,720	24,220	2,040	24,720	11,040	28,420	.....	60
*Medium peat on sand	209,000	15,940	520	26,360	5,940	28,000	3,880	.....
Peaty loam on sand	50,800	4,480	1,280	44,620	8,400	19,560	Often	Often
Peaty loam on rock	98,120	7,280	1,920	46,080	17,760	25,240	.....	40
Mixed loam	88,080	8,800	1,680	83,560	20,960	22,280	.....	40
Clayey muck	512,000	50,360	3,160	60,880	23,480	54,520	.....	40

*Amounts reported are from 2 million pounds of deep peat and medium peat.

Table 4.—Average pounds per acre in 6 million pounds of subsoil (about 20 to 40 inches).

Soil Type	Total Organic Carbon	Total Nitrogen	Total Phosphorus	Total Potassium	Total Magnesium	Total Calcium	Limestone present	Soil acidity present
*Deep peat	533,970	42,660	2,060	32,580	8,990	41,790	.....	270
Medium peat on clay	114,000	8,940	1,680	116,040	30,780	58,020	118,560	...
Medium peat on sand	119,460	6,300	1,140	64,800	66,000	574,620	1,472,940	...
Peaty loam on sand	19,380	1,800	1,530	74,340	14,670	20,160	.....	270
Mixed loam	69,720	5,460	1,920	139,260	36,300	27,180	.....	60
Clayey muck	345,900	22,440	1,860	100,020	43,140	58,440	.....	300

*Amounts reported are from 3 million pounds of deep peat.

DEEP PEAT.

Deep peat is found in comparatively small areas on both upland and terrace. It covers a total area of 2.73 square miles (1,748 acres), or 0.41 per cent of the area of the county. The soil to a depth of at least 30 inches consists of organic matter derived from mosses, sedges, and grasses.

The surface soil, 0 to 6⅔ inches, is a black or brownish peat somewhat decomposed. The drained areas have undergone greater decomposition because of better aeration, while the undrained areas have changed but little. The content of organic matter varies from 39 to 58 per cent, with an average of 46.5 per cent, or 230 tons in the one million pounds of the surface soil of an acre.

The subsurface soil, 6⅔ to 20 inches, consists of black or brown peat that usually shows the texture of the material from which it was produced. The organic matter content is about 31 per cent.

The subsoil, 20 to 40 inches, is ordinarily a brown peat, although in small areas sand or silt, almost invariably of a drab color, may form the subsoil below 30 inches.

Because of lack of drainage, this type of soil in Kankakee County has not been cultivated to a large extent. It is used mostly for pasture, and probably this is the best use to which it can be put. Tile drainage is not usually satisfactory because the soft peat soon permits the tile to get out of line and this seriously interferes with drainage. These soils fre-

quently contain alkali that irritates the skin. The term "itch dirt" is often applied to them. Where thorough drainage can be provided either by open ditches or by laying tiles deep enough to secure a solid bed for them, very marked improvement can be made in the productive power of deep peat by the liberal use of potassium, which is by far the most deficient element.

In Table 5 following are given all results obtained from the Manito (Mason County) experiment field on deep peat, which was begun in 1902 and discontinued after 1905. The plots in this field were one acre* each in size, 2 rods wide and 80 rods long. Untreated half-rod division strips were left between the plots, which, however, were cropped the same as the plots.

Table 5.—Corn yields in soil experiments, Manito field; typical deep peat soil (bushels per acre).

Plot No.	Soil Treatment for 1902	Corn 1902	Corn 1903	Soil Treatment for 1904	Corn 1904	Corn 1905	Four crops
1	None	10.9	8.1	None	17.0	12.0	48.0
2	None	10.4	10.4	Limestone, 4,000 lbs.	12.0	10.1	42.9
3	Kainit, 600 lbs.	30.4	32.4	Limestone, 4,000 lbs. Kainit, 1,200 lbs.	49.6	47.3	159.7
4	Kainit, 600 lbs. Aciduated bone, 35 lbs.	30.3	33.3	Kainit, 1,200 lbs. Steamed bone, 395 lbs.	53.5	47.6	164.7
5	Potassium chloride, 200 lbs.	31.2	33.9	Potass. chloride, 400 lbs.	48.5	52.7	166.3
6	Sodium chloride, 700 lbs.	11.1	13.1	None	24.0	22.1	70.3
7	Sodium chloride, 700 lbs.	13.3	14.5	Kainit, 1,200 lbs.	44.5	47.3	....
8	Kainit, 600 lbs.	36.8	37.7	Kainit, 600 lbs.	44.0	46.0	164.5
9	Kainit, 300 lbs.	26.4	25.1	Kainit, 300 lbs.	41.5	32.9	125.9
10	None	*14.9	14.9	None	26.0	13.6	69.4

*Estimated from 1903; no yield was taken in 1902 because of a misunderstanding.

The results of the four years' tests, as given in Table 5, are in complete harmony with the information furnished by the chemical composition of peat soil. Where potassium was applied, the yield was from three to four times as large as where nothing was applied. Where amounts of kainit and potassium chloride approximately equal in money value were applied, slightly greater yields were obtained with the potassium chloride, which, however, supplied about one-third more potassium than the kainit. On the other hand, either material furnished more potassium than was required by the crops produced.

The use of 700 pounds of sodium chloride (common salt) produced no appreciable increase over the best untreated plots, indicating that where potassium is itself actually deficient, salts of other elements cannot take its place.

Application of 2 tons per acre of ground limestone pro-

*In 1904 the yields were taken from quarter-acre plots because of severe insect injury on the other parts of the field.

duced no increase in the corn crops, either when applied alone or in combination with kainit, either the first year or the second.

Reducing the application of kainit from 600 to 300 pounds for each two-year period reduced the yield of corn from 164.5 to 125.9 bushels. The two applications of 300 pounds of kainit (Plot 9) furnished 60 pounds of potassium for the four years, an amount sufficient for 84 bushels of corn (grain and stalks). Attention is called to the fact that this is practically the difference between the yield of Plot 9 (125.9 bushels) and the yield obtained from Plot 2 (42.9 bushels), the poorest untreated plot.

Medium Peat on Clay.

Medium peat on clay occurs in swampy areas similar in location to those of deep peat, but it has not developed to a greater thickness than 30 inches. It covers a total area of 1.06 square miles (678 acres), or 0.16 per cent of the area of the county.

The surface soil, 0 to 6⅔ inches, is a brown to black peat, the amount of decomposition, which determines the color, varying with cultivation and drainage. It contains 37.4 per cent of organic matter.

The subsurface, which is the stratum between the plowed soil and the clay, is usually a brownish peat similar to the corresponding stratum in the deep peat. In the classification adopted by this station, medium peat varies from 12 to 30 inches in total depth to the earthy subsoil. Consequently, the subsurface varies greatly in thickness, but it is sampled to a greater depth of 20 inches. It contains about 23 per cent of organic matter.

The subsoil consists of a silty clay and almost invariably is of a light drab or bluish color owing to the deoxidation of the iron.

Drainage may be provided without unusual difficulty because tiles may usually be placed in the clay, which affords a good bed for them.

The treatment for this type is the same as for deep peat, but thorough trials should be made with potassium in advance for extensive use, for the surface and subsurface strata sometimes contain sufficient potassium in connection with mineral particles deposited from repeated overflows. (Note results of experiments hereinafter reported under "Peaty Loam on Rock.")

Medium Peat on Sand.

Medium peat on sand occurs in a few small areas in the

terrace region. It covers a total of 1.71 square miles (1,094 acres), or 0.26 per cent of the area of the county.

The surface soil, 0 to 6⅔ inches, varies from a brownish to a black peat, somewhat decomposed and mixed with more or less sand. The lack of uniformity as to sand content gives a wide variation in composition. As an average, about 38 per cent of organic matter is present.

The subsurface extends to a depth of 12 to 20 inches, passing into a drab sand, which continues to an indefinite depth. This stratum contains about 18 per cent of organic matter.

As in the case of the other peats, drainage is necessary before cultivation can take place. For the improvement of this type the same treatment is recommended as for deep peat.

Peaty Loam on Sand.

Peaty loam on sand occurs in areas somewhat similar to the preceding peaty types. It comprises 6.15 square miles (3,936 acres), or 0.92 per cent of the area of the county. The topography is flat.

The surface soil, 0 to 6⅔ inches, is a black peaty loam consisting of a mixture of white sand and organic matter. The relative amounts of these constituents vary quite widely, and within the type are found many areas, too small to be mapped separately, of peat and of sandy loam high in organic matter. The organic matter content of the surface soil averages lower than is ordinary for peaty loams, being as low as 10 per cent in places.

The subsurface soil is as variable as the surface. It usually passes into said at a depth of 12 to 24 inches. In general, the deeper the black soil extends the better adapted the type is to the growing of crops. This is especially true in the growing of truck crops, where the deeper soil is of decided advantage. This stratum ordinarily contains about 3 per cent of organic matter, but it varies greatly in this respect.

The subsoil varies somewhat, but it usually consists of a yellow or drabish yellow sand. Borings may frequently be procured that show strata of clay or silt a few inches in thickness.

Good drainage is the first requirement of this type. In general the methods for improvement are the same as for peaty loam on rock, described below. Most areas require the application of potassium in order to produce well. This is true especially of those areas where the soil contains little or no clay. Considerable feldspathic sand is present, but its potassium content is chiefly locked up in the sand grains and not susceptible of liberation by practical means. Alkali is fre-

quently present in sufficient quantities to do considerable injury, more particularly to the corn. The alkali is frequently of such a character that it irritates the skin, causing an itching sensation. Such soil is locally known as "itch dirt." On such soil manure usually gives temporary benefit, while thorough under-drainage will gradually remove the injurious alkali.

Peaty Loam on Rock.

Peaty loam on rock occurs in limited areas, occupying only 1.39 square miles (890 acres), or 0.21 per cent of the area of the county. It is found in areas similar in topography and drainage to those of the other peats and peaty loams.

The surface soil, 0 to 6⅔ inches, contains about 12 per cent or more of organic matter mixed with a large proportion of white sand. It varies in the same way as the peaty loam on sand. The subsurface as a rule contains more organic matter than that of the peaty loam on sand and is usually underlain by rock at depths varying from 16 to 30 inches.

Drainage is the first requirement of this type, but because of the underlying rock it is very difficult or almost impossible of accomplishment in some areas.

The Momence soil experiment field is in Sec. 6, T 30 N., 11 W., about 3 miles south of Momence, on peaty swamp soil (peaty loam on rock), which is underlain with impure limestone at a depth of 2 to 3 feet, with about 12 inches of yellow sandy subsoil between the black peaty soil and the underlying rock.

A part of Plots 101 and 102 and a smaller part of the other plots extend over somewhat different land, where the soil contains sufficient available potassium to produce a medium crop of corn in a good season, but most of the area under experiment is fairly representative of the most nonproductive phase of this peaty swamp soil. In Kankakee and adjoining counties, there are large areas of swamp soil of low productive capacity which will respond to the same treatment as this field.

Series 100 consists of ten tenth-acre plots numbered from 101 to 110. The treatment applied to these different plots is called a "complete fertility test."

It includes trials with applications of the elements nitrogen, phosphorus and potassium, singly, in all possible double combinations, and all three together. The plan will be easily understood by reference to the tables.

Nitrogen is applied in about 800 pounds of dried blood per acre each year. This furnishes about 100 pounds of nitro-

gen or as much as is contained in 100 bushels of corn. Of course the nitrogen is purchased and applied in readily available commercial form in order to ascertain as quickly as possible whether the soil is in need of that element. Where this is found to be the case it simply indicates that in farm practice more nitrogen should be obtained from the air by means of leguminous crops, as is being done in our rotation experiments, and not that commercial nitrogen should be bought and applied to the soil.

Phosphorus is applied in about 200 pounds of steamed bone meal per acre each year. This furnishes 25 pounds of phosphorus, or more than is contained in a 100 bushel crop of corn, the grain containing about 17 pounds and the stalks 6 pounds of that element.

Potassium is applied in the form of potassium chloride or potassium sulphate (each containing about 42 per cent of potassium). About 200 pounds of the salt is applied the first year, and 150 pounds per acre each year afterward. One hundred bushels of corn contain about 19 pounds of potassium in the grain and 2 pounds in the cobs, and the corresponding 3 tons of stalks contain about 52 pounds of that element. If the stalks are left on the land or all returned in manure, well distributed, the annual loss in potassium is only about 20 pounds for a very large crop of corn. Table 6, following, shows the results which were obtained during a period of fourteen years, 1902 to 1915. It should be stated that, although a small amount of lime was applied to certain plots in this field in the beginning of the experiment, the subsequent analysis of soil samples taken at the time the field was located shows that the soil is not in need of lime.

Table 6.—Crop yields in soil experiments, Momence field, 1902 to 1915.

TABLE 6—Crop Yields in Soil Experiments, Momence Field, 1902 to 1915.

Plot.	Soil Treatment Applied	Corn 1902	Corn 1903	Corn 1904	Corn 1905	Corn 1906	Corn 1907	Oats 1908	Corn 1909	Corn 1910	Corn 1911	Corn 1912	Corn 1913	Corn 1914	Corn 1915	Value of 14 crops: Lower prices[1]	Value of 14 crops: Higher prices[2]
		Bushels per acre															
101	None	6.9	14.9	4.8	6.8	6.8	.3	16.3	8.4	.3	9.2	5.8	7.0	1.0	2.8	$ 30.81	$ 44.02
102	Lime	5.5	7.1	*20.1	*33.9	*52.6	*14.9	23.1	16.0	.9	15.2	7.4	9.0	1.0	3.0	71.78	102.54
103	Lime, nitrogen	0.0	3.6	1.3	4.1	5.3	.4	15.6	3.8	1.1	8.2	3.8	5.6	1.6	2.8	18.93	27.04
104	Lime, phosphorus	1.3	4.6	.4	1.8	1.9	.2	14.1	1.2	.1	7.0	1.6	4.2	.6	.6	12.87	18.39
105	Lime, potassium	23.7	72.2	34.6	41.4	50.0	16.2	21.6	39.2	20.2	62.0	36.2	48.0	21.2	19.0	175.41	250.59
106	Lime, nitrogen, phosphorus	0.0	3.9	.6	1.6	4.5	.4	15.6	1.8	1.7	11.2	7.2	5.4	4.0	2.4	20.01	28.59
107	Lime, nitrogen, potassium	19.7	71.1	33.5	38.5	53.1	16.5	19.4	49.2	23.8	62.2	44.2	50.8	22.4	21.2	182.60	260.86
108	Lime, phosphorus, potassium	32.0	73.1	42.0	36.3	59.4	19.9	20.3	55.8	37.4	70.4	51.4	55.4	22.6	21.6	207.74	296.77
109	Lime, nitrogen, phosphorus, potassium	25.2	66.8	39.2	42.9	65.6	25.1	26.6	66.2	40.4	81.8	69.0	60.6	34.6	41.6	238.10	340.14
110	Nitrogen, phosphorus, potassium	24.1	70.4	[4]19.0	[4]24.8	51.3	23.4	26.6	61.2	29.0	65.2	59.6	50.6	22.8	34.2	194.91	278.44

[1]Corn at 35 cents a bushel, oats at 28 cents.
[2]Corn at 50 cents a bushel, oats at 40 cents.
*Potassium sulphate was applied to Plot 102 in 1904, 1905, 1906 and 1907.
[4]No potassium was applied to Plot 110 in 1904 and 1905.

During the fourteen years the field has been under the control of the University, thirteen corn crops and one oat crop have been grown. The average yield of corn on the four* plots receiving no potassium has amounted to but 3.6 bushels per acre, while the average yield of the four* plots treated with potassium, at the average rate of about 150 pounds of potassium sulphate per acre per annum, has amounted to 43.6 bushels.

At the lower prices (35 cents for corn and 28 cents for oats), potassium has increased the crop values by $163.10 on Plots 105 and 107, averaged, as compared with the average return from Plots 103 and 104. This gives an average annual return of $11.65 per acre for potassium costing $3.78 at 6 cents a pound, which corresponds to $50.40 a ton for potassium sulphate or potassium chloride (often incorrectly called "muriate of potash"). Under normal conditions potassium chloride is the most economical form to use, and when purchased in carload lots by the cooperation of a group of farmers, the cost is usually less than $45 a ton.

After potassium was applied, phosphorus then became of some value, increasing the returns from $175.41 on Plot 105 to $207.74 on Plot 108. The increase of $32.33 is not quite enough to pay for the phosphorus, which cost $35 at $25 a ton for steamed bone, but the comparison between Plot 107 (LNK) and Plot 109 (LNPK), showing an increase of $55.50, indicates that phosphorus may be profitable for use where both potassium and nitrogen are provided. This would require, however, that the nitrogen be secured by legumes grown in the crop rotation or applied in farm manure, as the increase from commercial nitrogen on Plot 109, even when the nitrogen was applied in addition to both potassium and phosphorus (compare with Plot 108), was only $30.36 for the fourteen years, while the cost of the dried blood was about $190.

In Tables 7 and 8 following are recorded the results from Series 200 and Series 300 of the Momence experiment field, for the years 1904 to 1914:

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*Plots 102 and 110 are not included in the averages.

TABLE 7—Crop Yields in Soil Experiments, Momence Field, 1904 to 1915.

Plot	Soil Treatment Applied	Corn 1904	Corn 1905	Oats 1906	Clv'r 1907	Corn 1908	Corn 1909	Oats 1910	Clover 1911	Corn 1912	Corn 1913	Oats 1914	Soy beans 1915	Value of last 8 crops	
		Bushels or tons (clover) per acre												Lower prices[1]	Higher prices[2]
201	None	14.2	11.4	29.4	0	9.2	19.0	36.9	.21	18.6	12.6	27.2	9.5	$ 46.86	$ 66.94
202	Residues	20.1	16.1	32.2	0	8.2	25.2	37.5	Turned	32.2	24.4	27.5	11.3	57.61	82.30
203	Manure	13.4	10.1	24.4	0	11.8	27.8	38.8	.23	35.8	24.6	23.8	11.2	61.98	88.54
204	Manure, cover crop	6.3	6.6	25.3	0	14.2	25.8	46.9	.44	36.6	17.0	34.1	10.3	65.73	93.90
205	None	4.4	5.6	21.2	0	8.2	17.0	48.1	.29	16.2	9.4	33.4	9.8	49.49	70.70
206	Phosphorus	8.7	8.6	23.4	0	14.0	16.0	51.3	.45	18.2	15.2	37.2	9.8	56.98	81.40
207	Residues, phosphorus	10.9	10.1	30.6	0	6.0	17.6	42.8	Turned	27.4	18.0	30.3	12.3	53.23	76.04
208	Manure, phosphorus	1.5	8.9	30.9	0	17.4	17.6	52.2	.80	41.8	12.6	35.6	11.7	69.66	99.52
209	Manure, cover crop, phosphorus	9.4	10.8	38.1	0	25.2	24.4	62.5	.58	51.6	23.6	41.9	12.3	85.58	122.26
210	None	6.5	10.0	29.4	0	8.6	14.4	45.0	.29	17.8	11.2	27.2	9.8	47.31	67.58

[1]Corn at 35 cents a bushel, oats at 28 cents, soy beans at 70 cents, clover at $7 a ton.
[2]Corn at 50 cents a bushel, oats at 40 cents, soy beans at $1, clover at $10 a ton.

TABLE 8—Crop Yields in Soil Experiments, Momence Field, 1904 to 1915.

Plot	Soil Treatment Applied	Corn 1904	Corn 1905	Oats 1906	Clv'r 1907	Corn 1908	Corn 1909	Oats 1910	Clover 1911	Corn 1912	Corn 1913	Oats 1914	Soy beans 1915	Value of last 8 crops	
		Bushels or tons (clover) per acre												Lower prices[1]	Higher prices[2]
301	Potassium	34.9	41.5	36.6	.10	20.2	44.4	35.6	.26	39.4	41.6	20.9	11.5	$ 76.65	$109.50
302	Potassium, residues	35.5	35.6	38.1	.28	12.4	54.0	38.8	Turned	38.8	43.6	26.2	12.5	79.03	112.90
303	Potassium, manure	41.1	44.1	40.3	.30	20.0	58.4	39.1	.67	49.8	47.4	26.9	12.0	93.03	132.90
304	Potassium, manure, cover crop	38.5	40.5	33.1	.10	22.6	47.2	40.0	.59	49.8	43.4	30.6	11.7	89.14	127.34
305	Potassium	42.9	45.2	41.2	.48	25.6	48.2	43.8	.71	44.2	45.0	31.6	11.8	91.39	130.56
306	Potassium, phosphorus	45.9	47.7	41.6	1.03	22.0	47.4	41.3	.98	52.0	42.2	30.0	12.3	92.69	132.40
307	Potassium, phosphorus residues	44.4	50.5	45.3	.40	15.8	53.6	40.0	Turned	45.2	41.6	29.1	13.0	83.12	118.74
308	Potassium, phosphorus, manure	54.4	54.9	44.7	.33	29.6	59.4	53.1	1.13	65.2	49.4	34.4	13.0	112.77	161.10
309	Potassium, phosphorus, cover crop, manure	52.2	55.5	45.9	.05	23.2	45.0	35.9	.98	57.8	45.4	39.1	11.5	103.73	148.18
310	Potassium	30.3	37.5	35.3	.08	16.2	45.0	35.0	.20	33.6	36.0	27.5	11.8	73.19	104.56

[1]Corn at 35 cents a bushel, oats at 28 cents, soy beans at 70 cents, clover at $7 a ton.
[2]Corn at 50 cents a bushel, oats at 40 cents, soy beans at $1, clover at $10 a ton.

The work was not begun on these series until 1904. A rotation consisting of two crops of corn, one of oats, and one of clover has been practiced. Instead of applying nitrogen in commercial form as on Series 100, the nitrogen has been provided in legume crops, cover crops, and crop residues in the system of grain farming, and in farm manures in the livestock system. The legume cover crops and crop residues have been made use of since the beginning, but no manure was applied till 1908, after the first clover crop of 1907. The manure was applied in proportion to the crop yields. Where larger crops were produced, proportionately more manure was subsequently applied; and, consequently, more manure was applied to Series 300 than to Series 200. The phosphorus was applied in the form of steamed bone meal carrying 12½ per cent phosphorus, at the rate of 200 pounds per acre per annum. No potassium has been applied to Series 200, but potassium has been applied to the whole of Series 300 at the rate of 150 pounds of potassium sulphate per acre per annum. Common salt (sodium chloride) was applied to the north half of all the plots of Series 200 at the rate of 600 pounds per acre in the spring of 1908. So far as it is possible to observe, no effect has been produced by the salt.

The land on which Series 200 and Series 300 are located is naturally more productive than that on which Series 100 is located. The untreated land of Series 200 will produce under favorable conditions 10 to 15 bushels of corn per acre. The south half of Plot 202 occupies the area of an old stack bottom. For this reason the yields from that plot are larger than normal, at least for the first three or four years. The yields from Plots 201 and 203 were also thus influenced but not to the same extent.

As an average of the returns from Plots 301, 305 and 310 (compare with 201, 205 and 210), potassium increased the crop values by $46.76 per acre during the four years 1904 to 1907, or by $11.69 a year, at a cost of $3.78, but during the next eight years the average yearly increase for potassium alone was only $4.07 which is not much above its cost. When used in addition to manure, the potassium did not pay its cost.

Plots 3 and 4, Series 200, received an average of 3.7 tons of manure per acre in the spring of 1908 and 5.6 tons in 1912. The return in the eight crops was $13.24 for the 9.3 tons, or $1.42 per ton. On Series 300 the corresponding return was $5.02 for 16 tons of manure, or 31 cents per ton, when used in addition to potassium. the manurial value of the cover crop on Plot 4 being included in both cases.

Phosphorus did not produce sufficient increase, at the lower prices for produce, to pay its cost.

The plain conclusion to be drawn from these investigations is that either potassium or manure should be used to begin the improvement of this type; and when good crop yields are secured, more and more manure should be returned, and the application of commercial potassium may then be greatly reduced, or possibly ultimately discontinued. Of course, if some other soil on the farm needs the manure even more because of deficiency in both potassium and nitrogen, one may use less manure and more potassium on the peaty swamp land.

Drying Peat (E. G. Lea, Br. Pat. 103,729, 1916). Peat is alternately compressed and broken up whilst being dried by artificial heat. Disintegrated peat is fed onto an endless band by which it is carried over a series of furnaces alternating with heated pressing rolls and having toothed breaking rolls above them. The chain, consisting of a series of flanged plates jointed together, passes around polygonal drums and is supported below the rolls by small rolls. One of the drums is driven by a belt and another belt drives the pressing rolls and the breaking rolls in opposite directions. The rolls are mounted in spring bearings and when heated by steam, are each provided with a pipe through which condensed water is blown when the vertical limb is in its lowest position. The end of the limb enters a groove in the inner surface of the roll.

Preparing Peat (G. Mondolfo, Br. Pat. 104,507, 1916). In the treatment of peat for rendering it suitable for fuel, the peat is first pressed and filtered to separate some of the moisture, and then disintegrated. During or before this process, conglomerating material may be added, which may be suitably chosen to increase the heating power of the peat. It is again pressed and then cut to the required shape and size and dried in a chamber at a temperature not exceeding 60° C.

Peat Briquettes (O. Walker, Br. Pat. 104,865, 1916). Briquets are made from peaty earth, humus, swamp ground, or other earth together with pitch, coal tar, or wood tar. Cinders, ashes, scoria, coal or coke dust, or sawdust, may also be added, together with sulphuric or nitric acid. In one example, 100 kilos of cinders are mixed with 10 kilos of pitch. The mixture is heated and 3 kilos of coal tar and 800 grams of sulphuric acid added. The mixture is then moulded and pressed into briquets. In another example, 66 kilos of cinders are mixed with 34 kilos of turfy earth, 10 kilos of pitch, 3

kilos of coal tar, and 800 grams of sulphuric acid. In a further example, 50 kilos of peaty earth are mixed with 35 kilos of sawdust, 8 kilos of coal tar, 3 kilos of pine resin, 1 kilo 500 grams of nitric acid, and 400 grams of sulphuric acid.

THE FUEL SHORTAGE IN ITALY.

Quite a number of peat bogs are being worked at the present time in Italy in order to secure a supply of fuel. Much of this peat is of too low a grade to compete with foreign imported coal, but more recently attention has been called to the nitrogen it contains. The most recent investigations in this direction have been carried out at Codigoro, and it is claimed that all the difficulties have been overcome. The peat, after drying and crushing, is taken to a furnace of the producer type some 30 feet high, into which it is fed at the top. The peat burns only at the bottom of the producer and the combustion is regulated by the use of a hot air and steam jet, and the steam is decomposed upon contact with the incandescent mass, thus producing a number of gases, and among them water gas, which rise to the top of the producer. This gas should be produced at the lowest possible temperature, and the nitrogen of the peat combines with the hydrogen in order to form ammonia. The gas thus produced is put through a scrubber to rid it of the particles of tar which it draws over, and from this it passes into a lead chamber where it comes in contact with a fine shower of sulphuric acid, which converts the ammoniacal gases into sulphate of ammonia, while the rest of the gas is purified, cooled and then can be used as combustible under steam boilers, in drying ovens, or can even be used as gas for internal combustion engines. By this process three-quarters of the nitrogen contained in the peat is said to be transformed to sulphate of ammonia, and peat containing 2.5 per cent nitrogen will give some 170 pounds of this product per ton. The plant at first treated 1,500 cubic feet of peat per day, and this gave 50 tons sulphate of ammonia per month, and the gas from it was used in an electric station of 800 horsepower capacity. The good results achieved led the experimenters to erect a second plant, and they are now treating 17,000 tons of dried peat annually, with an output of 10 to 12 tons of ammonia sulphate per day.—Indian Engineering, vol. 59, 1917, p. 201.

SCARCITY OF FUEL IN SWEDEN—SUBSTITUTES FOR COAL AND GASOLINE.

Swedish coal mines produce an average of 400,000 tons of coal annually. Much peat fuel and charcoal are also pro-

duced, but the steadily growing manufacturing industries and the merchant marine require increasing quantities of coal and coke, which must necessarily be imported. In 1913 Sweden imported 5,374,720 tons of coal and coke, of which 4,915,857 tons were from Great Britain, 408,641 tons from Germany and 50,222 tons from other countries. Since 1913 the coal import from Great Britain has decreased, owing to war conditions, as the following figures show: 1914, 4,563,076 tons; 1915, 2,659,995 tons, and 1916, 1,646,502 tons. This decrease was made up by imports from Germany.

It was impossible, however, to obtain sufficient quantities of coal and coke from Germany and the high freight rates and difficulty of shipping made it impracticable to import from America. It soon became apparent that the greatest frugality must be observed; trains were withdrawn by the railroads, steamship service was reduced by half, the use of gas was restricted to 60 per cent of the normal consumption, and some schools had to be closed for lack of fuel.

This situation caused considerable activity in woodcutting and charcoal burning, tests of peat and other low-grade fuels on railroads, erection of new peat factories, prospecting for undiscovered coal deposits, and increased attention to the Swedish coal fields on Spitzbergen. Experiments were made with electric heating for bakeries, and an invention for the manufacture of charcoal from waste lye from pulp mills was improved upon. Owing to the scarcity of gasoline new factories for the production of sulphite alcohol have been built and others are contemplated, and benzol is used somewhat as a substitute for benzine.

CHEAP ELECTRICITY IN IRELAND.

The comparatively high cost of electric energy in this country, says the "Irish Builder and Engineer," is largely responsible for the attitude adopted by the manufacturer to the introduction of electric power into his workshop. There is little hope for any considerable reduction in the rate until large central generating stations are established and until fuel is much cheaper, or water power can be substituted for steam and petrol. There has been under consideration for many years past a proposal to erect a generating station at some convenient center in the midland district of Ireland, where peat fuel can be readily obtained in large quantities, or else in the neighborhood of some of the anthracite seams which are known to abound in certain counties. Whether this scheme will mature within reasonable time is open to ques-

tion, despite the obvious advantages that would accrue to Dublin and other large Irish towns if electric energy for lighting and power could be supplied cheaply. At Washington the charge for energy for manufacturing purposes is only 1 farthing per kilowatt-hour, a rate that encourages both small and large manufacturers to instal electric plants. It is to be feared that many years will elapse before similar facilities exist in our own country.

PEAT FUEL IN RUSSIA.

The fuel problems of the country necessitated the organization of a special conference on the fuel question, a committee with full powers. On October 8 and 21, 1915, this conference published regulations fixing maximum prices on anthracite at 25 kopecks per pood ($7.13 per short ton, at the normal exchange rate). To relieve the situation existing at the time, steps were taken to increase the use of wood and peat in various industries, especially since wood was used as fuel in only 15 per cent of all the industries in the country.

The proportion of peat to the total fuel used in Russia was only one-third of 1 per cent. In this connection, mention should be made of a Moscow organization recently established, with a working capital of 9,000,000 roubles, for producing and selling peat.—Consular Report.

PEAT FUEL IN HOLLAND.

Fuel is doled out in small quantities. Each person must buy of a dealer of whom he has been a regular customer, or he gets no fuel. For coke, the only source of supply at the present time is the local gas works, where everybody goes. In some communities one must go in person to obtain fuel; no substitute will be recognized. There is no fixed time for obtaining fuel and no fixed amount obtainable. Both conditions depend on quantity and time of arrival of supply. Peat is not so limited, but everybody cannot have any quantity he may demand.

Prices of fuel have nearly doubled since the war began. This is true even of peat, a native product, of which, it is estimated, there are fully 100,000,000 tons in the moors of Holland.—Consular Report.

MEASURES TO PROTECT HOLLAND'S FUEL SUPPLY.

Holland is already taking steps to prevent a recurrence next winter of the suffering occasioned by a lack of coal during the past winter.

Hitherto the Royal Coal Distribution Bureau has concerned itself only with the distribution to large industries of coal, briquets, and mine coke. It will now supervise the distribution of all other kinds of fuel, including gas-works coke, turf, and turf briquets.—Consular Report.

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Postponement of Annual Meeting

As our members have already been advised, the 1917 Annual Meeting, which was to have been held at Minneapolis in September, has been postponed until 1918.

At the request of our President, Mr. L. B. Arnold, the Executive Committee was urged to study the advisability of postponing the annual meeting.

After thorough deliberation and receipt of expressions on the subject from various members, the Executive Committee was guided by the majority, who requested a postponement until 1918.

It is true that the annual meetings bring forth a large amount of valuable information and this alone makes the meetings worth while and profitable. However, in our present crisis, scientific and technical societies are only meeting to discuss those subjects which are of immediate interest and assistance to the government and "Our Worthy Cause." Hence, the Executive Committee, realizing that most of our members who attend our conventions find their presence at home is so urgently required that the majority would be unable to attend this year, acted well in postponing the meeting.

PEAT FUEL AND THE WAR.

The old saying that "It's an ill wind that blows nobody good" seems particularly applicable to the peat situation just now. The great war, among other epochal results, is creating an unprecedented shortage of coal in many countries. As a consequence, attention is being focused on the possibilities of utilizing peat for fuel. Our readers will find this phase discussed in several articles presented in this issue. Not only individuals and corporations but even governments are erecting plants

for the preparation of peat fuel and every effort is being made to develop methods of efficient and economical utilization. Never before were the prospects so promising for the development of peat-production plants adequately financed for the installation of efficient machinery of correct engineering design and for withstanding periods when the plants cannot be operated at a profit. Failure in these two features has accounted for the past failures of many peat fuel enterprises.

As is mentioned elsewhere, a most favorable result of present efforts to increase the use of peat fuel may be that its use may become so firmly established that even after the war, when coal again becomes a strong competitor, a vastly increased demand for peat fuel will continue.

MANUFACTURE AND USES OF PEAT.

By W. F. Todd, St. Stephen, N. B., Canada.

(Read at the Washington Meeting, Sept. 21, 1916.)

At the request of your President and Executive Committee I have pleasure in writing a paper on peat moss, which I have varied as far as possible from my former article in the Journal of October, 1913. It would have been a rare pleasure to me to have been able to attend the annual meeting, for two reasons—first, that I might meet the officers and members of the Society present; second, that by my presence I could join with you in giving expression to our common feeling of sadness that will pervade your meeting at the absence and loss of our very able and valuable member and editor, the late Professor Davis. In his death the American Peat Society, as well as his family, have met with a great loss.

I never had the pleasure of meeting Professor Davis, but expected a visit from him during the summer just passed. My correspondence with him has extended over a period of nine years. In all that correspondence and in his published writings I have ever found him imbued with the brightest hopes for the future of our peat bogs and their products, which promise to enter largely into industrial uses. He was ever ready to help with his large knowledge; always reasonable and practical in his views upon peat matters, and always animated with an intense desire to forward the cause for which our Society is so nobly working. His death has brought a great loss to us all.

My reason for using the term "peat moss" is that the term is used in Europe generally, and most nearly represents

the product to which this paper is almost entirely devoted. There are different kinds of bogs, classed according to the vegetable material that makes up the greater part of their whole. But the moss formed, or the sphagnum bogs, have at present by far the greatest potential value, and bulk largest in peat-bog work abroad. These sphagnum or turf-moss bogs inhabit chiefly the temperate and cold zones in either hemisphere. If they occur in hot zones, it is on high mountains or on the brinks of cold springs, under conditions approaching those of the cold zones. Rain, fog, and moist air conduce most to their quick and luxuriant growth, because the absorptive power of these sphagnum mosses is as strong from the upper part to the lower as from the lower part to the top, so that a foggy or humid atmosphere will penetrate them from above as well as the water of the bog from below. Therefore their growth is faster and greater near the seacoast, where the best type of sphagnum or peat-moss is found. Upon bogs or moors of this kind, upon which I have worked, the moss is almost entirely Sphagnum Fuscum var. Fucescens, and in depressed parts of the bog growths of Sphagnum Tenellum var. Rubbelum abound. Some other varieties of sphagna grow about the edges of the bog or along the water runs, but most of the bogs are composed of the two kinds named. These possess the very highest absorptive powers of the Sphagna family, and by this power have proved of great value.

I need not take up your time in speaking of the other plants that make up the bog. The names and kinds of these general bog plants are fully known to you. Their abundance or scarcity on top is measured by the age of the moss growth, the number of burnings, if any, that have taken place on top or by the sinking of the water plane from this cause, or by the breaking away of any of the walls of these former lakes or ponds (now bogs), causing the water level to be so lowered that the moss growth on top is stopped. Some bogs, because of the rapidity with which they have been formed, can be used as a source of peat moss clear to the bottom, but the large majority of peat-moss bogs or moors, owing to great age whereby a greater humification of the lower layers of the dead moss takes place, are suitable only for fuel or agriculture in their lower layers, the upper layers only supplying satisfactory peat moss. A large industrial field for work looms up in the working of these bogs and the employment of capital in this work will, I feel sure, bring large returns. The bogs are numerous in the northern and eastern parts of North America. The products to be obtained from them are many and varied. They are needed for the comfort of man.

I will now take up some of the uses that have been made of peat moss. They are many already, but more uses for this material will be found in the future, when the working of these bogs takes place as it should. I deem it best to group these uses and comment as briefly as possible upon them.

Some of the products that can be made from peat-moss bogs are alcohol, ammonium compounds, artificial wood, peat coke, peat charcoal, peat distillates, peat gas (illuminating, water, fuel, or producer), fuel for generating electricity, peat powder, nitrates, dyestuffs, tanning material, paper and pasteboard, textile or woven fabrics, such as rugs, blankets, clothing, carpets, bandages and yarn; peat or turf wool, surgical dressings, and filling for pillows or mattresses.

The above products require the installation of costly plants. The manufacture of most of them has not yet been developed to a commercially successful state, and the investment of capital to work peat bogs for these lines is not yet advisable, in my opinion. The generation of electric power through producer gas from peat has an alluring aspect, but in most places water or coal power plants are established, and a stiff, profitless competition ensues until one or the other is obliged to retire from the field.

But there are many uses for peat and peat moss which should in time attain to large sales and which will require only a fairly small outlay of capital for manufacture. Let me mention some of these—peat fuel, top moss for florists' use, and the packing of plants and trees, for growing certain plants such as orchids, hoof dressing, as a fertilizer filler, as a lining and packing for ice-houses, as litter for horses, cows, pigs, and poultry, as mull or powder for packing breakable goods and bottled liquids, for packing fruit, meat, or fish, for the taking up of sewage, and for use in outhouses or privies.

As I have stated before, the two most promising fields for the use of peat moss are, in my opinion, for sanitary purposes and as a litter under animals and fowl. In these two uses you meet the wants and needs of a large proportion of the people, furnish a great aid to their comfort, and assist in the conservation of material, which should help largely in cutting down the cost of agricultural products.

Fuel, in our northern climate, must be considered one of the very first necessities, but peat fuel is not a product of the peat-moss part of the bog, that I am now discussing. It is a product of the lower layers of a mixed peat-moss bog. The preparation of moss for the two uses mentioned last would be largely the same, and it could be in this form applied to a number of other uses of peat moss that I have enumerated.

In my article on peat-moss litter, published in the Journal of October, 1913, I stated fully my claims for the use of peat moss for sanitation and litter, and gave full directions for using the latter. The fair length to this paper will not allow me to repeat these claims and directions.

This fact stands out bold and clear—that the sphagnum peat mosses have the unique and valuable property of absorbing gases as well as liquids. Wherever the fecal evacuations in cities, towns, or other districts are not carried away by a modern sewerage system, then through cesspolls, or other places of deposit, the air is often poisoned by the escape of noxious gases, often causing epidemics and infectious diseases. Peat moss, when mixed with such matter, not only prevents the escape of noxious fluids and gases, but also checks the growth of injurious micro-organisms, thus rendering it innocuous and agreeable to handle, and furnishing to the market gardener and farmer one of the very best of fertilizers. A like result obtains when the moss is used under animals or poultry. Besides the great manurial value of these evacuations, the peat moss absorbs and locks up these fertilizing riches, adding its own content of nitrogen, and when incorporated with the soil unlocks (through bacterial action) for plant growth, all the fertilizing elements it has received, besides making the soil more retentive of moisture. When we consider all this, it shows clearly what a vast field for the use of peat moss is open to us. It needs only capital and untiring push and energy to reach the goal this industry can be made to attain.

As litter under animals, peat moss should have wide use. It lasts much longer than any other bedding; keeps the animal healthier, disinfects the stable, requires less work, and maintains perfect freedom from likelihood of fire in the stalls when used alone, without a covering of straw.

The importation of peat moss into the United States has increased only slightly, the increase during the past 35 years having been only about 5,000 tons. About 8,000 tons is the present yearly importation. In 1912 Great Britain and Ireland, with a population of 45 millions, used about 185,000 tons, nearly half of which was imported from the continent. The United States, with a population of 100 millions, used only 8,000 tons. How can you account for it? If a conservative people like the British are using such large quantities they must find great virtues in its use. I account for the small use of peat-moss litter in this country for three reasons—first, because no moss-litter factories are manufacturing moss litter

in this country; second, because it is only a side line with the importers, and hence they have no great incentive to push it; third, because of its condition when opened for use in stables. It is said that the average moisture content of peat-moss litter when gathered on the moors of Europe, for baling and shipping, averages 50 per cent. Between baling time and the time it is bought by the user, a large shrinkage has taken place, and the bales do not show the weight as invoiced. This causes objection on the part of the consumer, or results in loss to the importer. But, in my opinion, the most serious drawback to the wider use of imported peat moss is the hard, lumpy and leathery condition of the moss when the bales are broken open for spreading in the stalls. The stable men will always object to pulverizing these lumps and the owner objects to putting his stock on such a hard bed. Of course, this litter in time will become a nice, soft cushiony bed, but it takes weeks of trampling of a restive horse to produce this state. This serious objection to the condition of imported peat moss is occasioned by the method of manufacture upon European moors. By exposure to the glaring sun on the peat fields, the moss blocks become baked by the heat on their surface and for some distance in, making them tough and leathery, and the toothed disintegrators used do not adequately break them. Consequently the moss comes to this country in the condition I speak of. In manufacturing peat moss in this country, this condition must not be allowed.

The agricultural uses of peat are increasing year by year, and soil bacteriology and study is opening up a vista that looks very bright for a large use of the deeper parts of our bogs. As to peat fuel, it is said that 20,000,000 tons of peat fuel are used in Europe annually. This proves it is a good fuel. Why is it not manufactured and used largely on this continent? We have as good peat. Millions of dollars have been expended on this continent to manufacture fuel from peat and sell it. Yet no peat-fuel plants, to my knowledge, are manufacturing and selling fuel today in this country. Many have started; some may be now in the initial stage, but no large and profitable business in peat fuel has yet been attained in this country. Though never having worked with peat, I have certain ideas upon the working and the future of peat fuel in this country. Where the subject is always open to discussion among our members, I take the liberty of presenting in this paper some of my ideas on this subject in the hope that they may be helpful.

Over all Europe, peat fuel is manufactured, almost entirely, by the wet-process, open-air-drying system, which is

dependent upon the weather, and has an average working season of only 90 to 100 days. Labor there is low; contracts for piecework in all the steps of manufacture can be easily made, while the good qualities of the peat fuel, tested fully by years of use in those countries, have become fully known to the people. In this country I do not think the present European system of manufacturing peat fuel is profitably workable on account of larges wages, inability to get piecework done, shortness of season, and uncertainty of weather conditions, all of which make the cost of production very uncertain and delivery ever in doubt. In the working of a mixed peat-moss bog, it is of prime necessity to utilize the lower layers for peat fuel. To sell it the price must be low, and the selling area limited probably to a radius of 50 to 75 miles. No dry-briquetting process has as yet proved successful here or abroad. The cost of manufacture is largely the reason. Peat powder is partly in an experimental state, is not applicable to general use, and the cost of plant will be high.

This paper, gentlemen, has already, no doubt, proved too long; hence I will speak only briefly of peat and peat-moss manufacture from the standpoint of my own experience and observation of this material. You will say that I have drawn a rosy picture of the many uses of the products of the peat-moss bog; that I show no hope in the present-day methods of manufacture for the reasons set out, and that as yet I have brought forward no solution of the difficulty as I see it. He would be a bold man, gentlemen, who in the light of past history of peat work, would say that he had a process of manufacture that was unassailable from any side. My work and enthusiasm in the cause of the development of our peat deposits have brought certain results, so that I feel I can speak with some authority upon the subject. I must be very brief, for this paper must go out in the mail that will soon leave.

I do think that there is a way of working these deposits that is not at the mercy of the weather, is not limited to a short season, and is reasonable in cost. First, I would select the bog with a great deal of care and testing; secondly, I would use machinery to do every bit of work possible. I would never drain the bog. Dig from the top by machinery on the continuous-scraper principle, if character of the deposit allows, and dig to the bottom. I would press out all the water that was economically possible and make briquets of the peat while wet. I would use all Nature's helps that I could, but I certainly would make use of artificial heat wherever necessary.

With the proper capital I feel very sure that a plant could be erected to work successfully the whole year round, and I trust in due time to prove that my ideas in this regard are sound.

PEAT AS LOCOMITIVE FUEL IN SWEDEN.

Reports from Sweden appear to be very favorable as regards the use of peat as a fuel for steam locomotives, the peat being dried and powdered, and employed in the latter state, which is affirmed to be the best for firing locomotive furnaces. The government railroad administration recently appointed a commission to make a thorough examination of powdered peat as a fuel, and after a series of tests upon the preparation and combustion of this substance, the commission reported in its favor, stating that the results were conclusive. The report established the fact that powdered peat can be satisfactorily utilized as a fuel and concluded it should be employed on a large scale.

Accordingly the Swedish government is taking measures to erect a plant of considerable size near the peat fields of Lake Vetter for making peat dust. As to the use of this fuel on locomotives, it is stated that all the locomotives on the 60-mile Falkoping-Nassjo railroad line are now running on peat fuel with great success. The official tests showed that the calorific power of peat fuel (by weight) is about two-thirds that of coal. The results already attained are claimed to justify the erection of large plants to utilize this national resource.

In order to keep peat production for this use clear of complicated questions regarding competition from coal, the government decided to have the new plants operated by the state, at least for the present, and is now engaged upon the plans for utilizing several large peat beds. For instance, the Hasthagen fields would afford some 20,000 tons of powdered peat per annum, and on this basis the beds would not be exhausted within 20 years. After the peat is removed, the ground can be used to advantage as farm land.

Peat a Source of Heat and Power

Prof. Peter Christiansen, St. Paul, Minn.

(Read at Washington Meeting Sept 22, 1916)

There are three methods of utilizing solid fuel, viz: (A) Using it in lump form by burning it on an ordinary grate area; (B) burning it in a pulverized condition—spraying it by means of air into a combustion chamber of a furnace, and (C) first, gasifying the fuel in a gas producer, and second, burning the resulting producer gas (a) in the combustion chamber of a furnace to generate heat, or (b) in an internal-combustion engine to generate power.

Of these three methods the first is sometimes called "direct firing." It is the original method and is still the one most commonly used. The second is the "powdered-fuel" method. This is the method latest improved. Its development, to a large extent, is due to a desire of producing conditions similar to those of burning fuel oils. In this method a special preliminary pulverization of the fuel is necessary. The third method is sometimes referred to as "gas firing." This is the most scientific but may also be regarded as the most complex.

Each of the above methods is applicable to the use of peat. The difference between the use of peat and coal is only a matter of detail, owing to the different conditions in which these two fuels occur. The differences between peat and coal are (a) moisture content and (b) physical condition. Coal is mined in solid form. The pieces produced vary in size from fine powder to lumps of considerable size and in moisture content from 1 to 10 per cent. Peat as excavated from the bog has a spongy consistency and carries about 90 per cent of water with only 10 per cent of solids. On account of its spongy condition and excessively high moisture content, peat before it can be utilized must pass through an extensive preliminary preparation. It makes no difference whether the peat is used in "direct firing," "gas firing," or as "powdered fuel," preliminary preparation is necessary.

Machine Peat.

For direct firing the simplest form of preparation is required. An outline of this preparation may be summarized as follows:

(1) Excavation of the peat material, containing 90 per cent water, from the bog.

(2) Maceration or thorough disintegration of the excavated peat material so as to give it a uniform consistency capable of being molded into shape. This maceration gives the material coherent properties so that when molded and dried, the resulting blocks can be handled like coal.

(3) Molding the macerated material into the form and size of ordinary brick.

(4) Allowing these peat bricks to dry by exposing them to the atmosphere.

Peat prepared in this manner is technically known as machine peat. It contains 25 to 35 per cent moisture, varying with the moisture conditions of the atmosphere. In this form peat is in proper condition for burning on a grate similar to that used for coal. On account of its low heating value about twice as large a grate area is required for peat as for coal, to produce an equal amount of heat. Because of the large grate area necessary and because of the bulky nature of this machine peat, its use will probably be limited to domestic purposes and to the firing of stationary boilers.

Powdered Peat.

The first or preliminary preparation of powdered peat is similar to that of machine peat, namely, excavation, maceration, molding and drying. These processes may be more or less modified to meet the requirements of the subsequent operation. The second or final preparation is similar to that for powdered coal. However, the details are different because the material treated is less compact and will contain 30 to 40 per cent moisture, whereas coal seldom contains over 5 per cent moisture.

An outline of the pulverizing process may be summarized as follows: First, crushed in rolls similar to those used for coal; second, pulverized in a special pulverizer; third, screened; fourth, dried in a special rotating dryer; fifth, screened; and sixth, the oversizes from the fifth operation pass to other screens and pulverizers. The undersizes from operations five and six constitute the final product of powdered peat which contains from 12 to 15 per cent moisture. An outline of the Ecklund method of producing powdered peat, as used at Backmossen, Sweden, was given in the Journal of the American Peat Society, vol. 7, No. 1, p. 5. A calculation of the cost of production was also given in the Journal, vol. 4, No. 1, pp. 28-34. Of course, the figures on costs would have to be greatly

modified to make them applicable to conditions in the United States.

The third or final step is that of burning the powdered peat. The principle underlying this is the same as that underlying the burning of gas, oil, or powdered coal, namely, a fuel in a finely divided condition can efficiently combine with the oxygen of the air to produce complete combustion with a minimum supply of air, when the proper conditions are present. To get the proper conditions is the important consideration, and requires, first, that the fuel be uniform and finely divided; second, that it be intimately mixed with the proper proportion of air; and, third, that this mixture of air and fuel be maintained at a temperature high enough to enable the process of oxidation to continue until completed.

These conditions are most easily brought about with gas and for this reason gas is the most convenient form of fuel. In fact, the gasification of solid fuel, the atomization of liquid fuel, and the pulverization of solid fuel, each serves the same purpose—to put the fuel into a finely divided condition so as to meet the first requirement. The second and third requirements are less easily obtained with atomized fuel than with gas, and still less easily obtained with powdered fuel.

For this reason the burning of powdered peat has not until recently been successful. However, the difficulties appear to have been overcome by the invention of Mr. Von Porat. According to an announcement in the Journal of the American Peat Society, vol. 6, No. 4, p. 160, a number of the Swedish railways are now prepared to use powdered peat in the place of coal.

When using powdered fuel the essential condition is that the powdered material be projected into the combustion chamber of the furnace in such a manner as to keep the powder suspended in the combustion space until the particles are completely burned. If the material be uniformly fine and the feed absolutely constant, complete combustion can be obtained in an ordinary combustion chamber, in which an excess of air can be reduced to a minimum by keeping the firebox closed. The requisite volume of air for combustion is forced into the furnace and enters the combustion chamber through the pipe which also carries the fuel. When successfully carried on, this method of firing eliminates smoke and gives a maximum efficiency.

Gas Firing.

The preparation of peat for gas firing is also similar to that for direct firing, namely, excavation, maceration, and

drying. Its function is to eliminate as much moisture as possible and to put the material in condition to be easily handled. Gasification of this prepared material is the next step.

In general it may be stated that the combustion of a solid fuel involves the following distince prenomena: First, vaporization of the moisture; second, volatilization of the hydrocarbons; third, gasification of the nonvolatile carbon; and fourth, oxidation of the resulting combustible gases. Of these the first and second absorb heat, that is, tend to reduce the temperature of the combustion chamber. The third and fourth evolve heat and are the sources from which all the heat is obtained.

It so happens that the sequence in which these phenomena take place in a furnace is about in the order given. Hence the process of combustion can be separated into two distinct and independent steps. The first will consist of vaporization, volatilization, and gasification. These three phenomena can be made to take place in a preliminary furnace, which technically is known as a gas producer. The product of this operation is a combustible gas which can be utilized independent of the preliminary furnace. The utilization of this gas is the second step in the process.

The essential features of a gas producer are a deep firebox with a perforated bottom to allow a uniform distribution of the air, and a closed top to permit the resulting gases to be collected and conducted away for subsequent use. The essential features in the operation of a gas producer are: (a) To keep the fuel in this deep firebox at a constant depth, at a constant temperature, and in a uniformly porous condition, and (b) to force air, more or less saturated with steam, through this porous fuel bed, so that all of the mixture of air and steam will come into intimate contact with the fuel. The depth of the firebox should vary with the character of the fuel, and the proportions of air and steam should vary with the temperature of the fuel in the firebox.

The essential constituents of the resulting gases are:

	Per cent.
Nitrogen	55
Hydrogen	10
Carbon monoxide	20
Carbon dioxide (as impurity)	5
Marsh gas	2

The proportions of these constituents vary somewhat with the skill with which the producer is operated.

Mixed with the essential constituents are tars, ammonium compounds, and moisture. The proportions of these non-

essential constituents vary with the nature of the fuel and the type of producer. They form the source from which a series of valuable by-products can be saved by suitable apparatus. The most important of these by-products are crude tar and ammonium sulphate. However, the saving of these by-products requires an expensive installation which is not economical for plants of less than 2,000 horsepower.

If the gases are to be used for fuel, the tars form a valuable source of heat, especially when high temperatures are desired. Therefore for such use the tars should remain in the gases. If, however, the gases are to be used in gas engines, they must be cooled and all condensable constituents removed.

The advantages of the gas producer may be considered in regard to two features—the production of heat and the production of power.

Production of Heat.

The total heat produced by the burning of a fuel is the sum of (a) the gasification of the nonvolatile carbon, (b) the oxidation of the gasified nonvolatile carbon, and (c) the oxidation of the volatile carbon together with the hydrogen combined with the volatile carbon. The proportions of the total heat represented by each of the above sources vary more or less with the nature of the fuel. For the purpose of explanation, it may be assumed that 20 per cent of the total heat is evolved by a, 60 per cent by b, and 20 per cent by c. This assumption may be considered typical of results obtained when using bituminous coals. According to this assumption, 20 per cent of the total heat will be generated in the gas producer and serve the purpose of supplying the heat absorbed by vaporization and volatilization, while 100 minus 20, or 80 per cent, will be contained in the resulting producer gas.

The purpose of burning fuel is to make as much heat available for external use as possible. By external use is meant heat applicable to purposes other than that required by the process of combustion itself. Hence if the heat-absorbing phenomena are separated from the heat-producing phenomena, the latter can be made more effective. This separation is precisely what is accomplished in the gas producer. Here all the heat-absorbing phenomena take place, while at the same time only a sufficient amount of heat is produced to enable the process to be carried on. In other words, the gas producer is a preliminary furnace in which only the requisite amount of heat to gasify the fuel is generated, leaving the reminder available for external use. This remainder is in the

form of a combustible gas and is equal to about 80 per cent of the total heating value of the fuel.

There is no other process available for the gasification of solid fuels whereby so large a proportion of the original heating value of the fuel can be made available in the resulting gas. The heating value per unit volume of producer gas is very low but the volume per unit of fuel is very large.

The following table illustrates the results obtained in gasifying the same coal by two different methods:

		PRODUCTS					
		Gas				Coke	
Pounds of fuel	Gasifying process used	Volume produced, cu. ft.	Heating value per cu. ft., B. t. u.	Total heating value, B. t. u.	Per cent of total in coal	Pounds	Total heating value, B. t. u.
2000	Gas producer	140,000	150	20,000,000	80	None	None
2000	Dry distillation	12,000	700	8,400,000	32	1400	17,000,000

In the gas producer, experiment has shown that the volume of gas per unit weight of fuel varies directly with the grade of the fuel, therefore, the better the fuel the more gas will be produced. On the other hand, the heating value of the gas per unit volume is practically constant and varies only with the skill exercised in operating a properly designed producer. Thus a low-grade fuel like peat will yield a gas with as high a heating value per unit volume as the better grades of coal but its yield, in volume of gas, will be less. Hence, it is easily seen that, by the use of the gas producer a low-grade fuel like peat can be utilized for the same purposes as the better grades of coal. The only difference is that it will take more of such a fuel to do the same work.

Producer gas may be used as a fuel for heating, and thus used it has all the advantages of any gaseous fuel. These advantages may be summarized as follows: No handling of fuel or ash; ease of regulation, and hence more constant and reliable temperature; less loss of heat owing to excess of air and incomplete combustion; perfect control of the atmosphere of the furnace; and production of high temperatures by applying the sensible heat of the waste gases to the heating of both the gas and the air before combustion.

Production of Power.

For power there are two methods available—burning the producer gas under boilers to generate steam, and using the producer gas in gas engines. The former method should be used only in a plant requiring a limited amount of power, or where the boilers and steam engines are already installed, or where the boiler plant is required to furnish steam for purposes other than power. For example, a boiler plant is usually an auxiliary part of a producer-gas plant. It is used to generate the steam used in the producers. The function of this steam is to saturate the air entering the producer, so as to keep the temperature of the producer down to that required for the producer reactions, and also to enrich the resulting gas with hydrogen.

When steam is generated in this manner the efficiency of the boilers and producers taken together will compare favorably with that of a boiler plant operated by "direct firing," and all the advantages of using a gaseous fuel are obtained.

Producer gas used in a gas engine gives by far the highest efficiency. The gas engine in its simplest form has proved itself to be at least twice as efficient as the most efficient steam engine. In round numbers, the gas producer method eliminates 80 per cent of the transformation of energy that takes place in the boiler plant. A gas producer in which only 20 per cent of the total heating value of the fuel is liberated is at least equal in efficiency to a boiler plant. Hence the combined efficiency of the gas producer and the gas engine is equal to twice the combined efficiency of the boiler and the steam engine. In the case of power plants of 2000 horsepower, to the above advantages should be added that of the by-products. These under ordinary market conditions will pay for both operating expenses and raw material.

If by using boilers and steam engines, it takes 2 pounds of coal to generate 1 brake horsepower, it will take only 1 pound of coal to generate the same power by the use of gas producers and gas engines. As 2 pounds of dry peat (moisture free) is equivalent to 1 pound of coal, it follows that 1 pound of dry peat will do the same work when utilized in a gas-producer gas engine as 1 pound of coal utilized in a direct-fired steam engine with boiler.

The relative costs of these two kinds of installations based on a 1000-horsepower unit would be as follows: Cost of "coal-boiler-steam-engine" installation $67 per horsepower. Cost of "peat-gas-producer-gas-engine" installation (without by-product plant) $72 per horsepower.

The following calculations will serve to determine peat area and capacities of peat excavators required for power plants.

Assumptions:

Working depth of peat bog, 5 feet.

2000 pounds of dry peat (moisture free) will occupy 220 cubic feet in bog.

120 working days on peat bog per year.

24 working hours per day.

2 pounds of dry peat in gas producer required per horsepower per hour.

Air-dried peat contains 25 per cent moisture.

(A)—Plant to produce air-dried peat for domestic use and boiler firing:

Capacity of plant, 10,000 tons dry peat per year, or 13,333 tons air-dried peat per year.

(a) Acres of peat bog required per year:

1 acre of peat bog 1 foot deep=43,560 cubic feet.

1 acre of peat bog 1 foot deep will contain $43,560 \div 220 = 200$ tons dry peat.

1 acre of peat bog 5 feet deep will contain $5 \times 200 = 1000$ tons dry peat.

Hence, 10,000 tons of dry peat will require 10 acres, and 10 acres of peat bog will yield 13,333 tons of air-dried peat.

(b) Capacity of machinery required for excavating the peat:

13,333 tons air-dried peat is equal to 10,000 tons dry peat.

10,000 tons of dry peat will require the handling of $10,000 \times 220 = 2,200,000$ cubic feet peat in bog.

$2,200,000 \div 120 = 18,333$ cubic feet per day.

$18,333 \div 24 = 755$ cubic feet per hour.

$755 \div 60 = 14$ cubic feet per minute.

(B)—1000-horsepower gas-producer plant.

(a) Acres of peat bog required per year:

1 horsepower-year = 8,760 horsepower-hours.

8,760 horsepower-hours will require $8,760 \times 2 = 17,520$ pounds of dry peat.

1,000 horsepower-years will require $17,520 \times 1,000 = 17,520,000$ pounds dry peat.

17,520,000 ÷ 2,000 = 8,760 tons dry peat.

8,760 ÷ 1,000 = 8.76 acres of peat bog required per year.

(b) Capacity of machinery required to excavate the peat:

8,760 tons dry peat will occupy 8,760 × 220 = 1,927,200 cubic feet in bog.

1,927,200 ÷ 120 = 16,000 cubic feet per day.

16,000 ÷ 24 = 670 cubic feet per hour.

670 ÷ 60 = 11 cubic feet per minute.

(C)—2,000-kilowatt gas-producer plant.

(a) Acres of peat bog required per year:

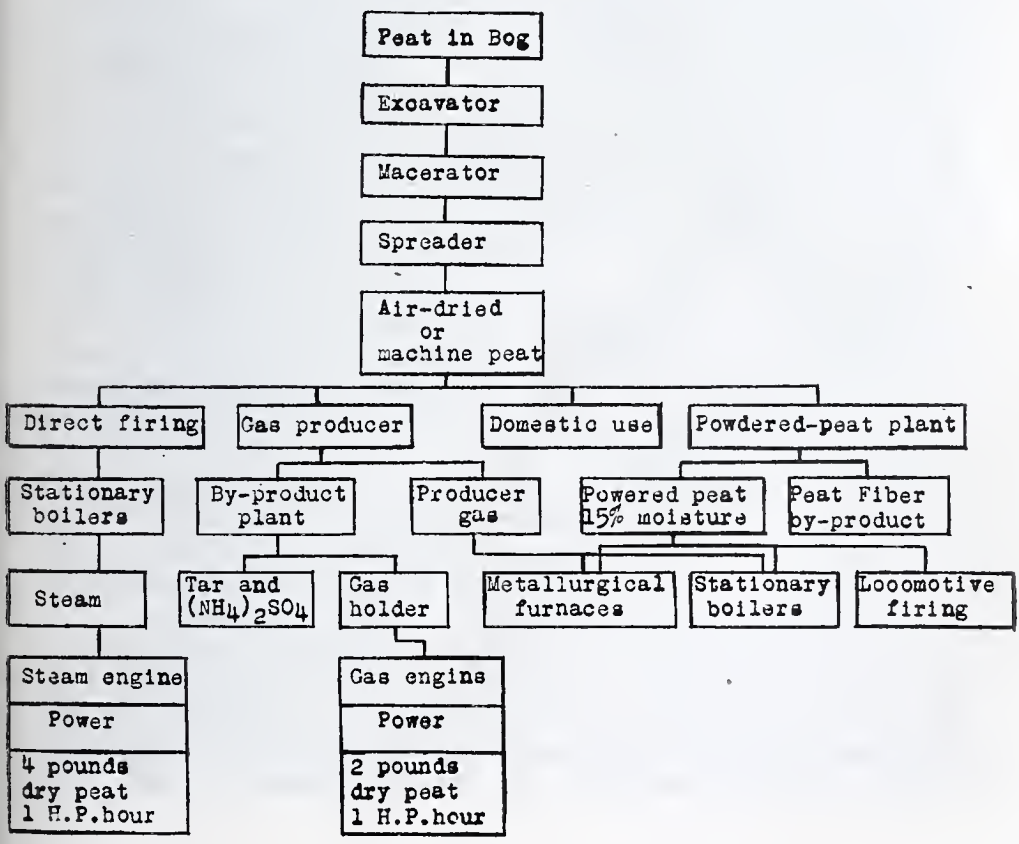
1 kilowatt = 1⅓ horsepower.

8.76 × 2 × 1⅓ = 22 acres of peat bog required per year.

(b) Capacity of machinery required to excavate the peat:

11 × 2 × 1⅓ = 30 cubic feet per minute.

DIAGRAMMATIC SUMMARY



The Value of Peat Fuel for the Generation of Steam

The Canadian Department of Mines Bulletin No. 447, by John Blizzard, forms the third and last of the series comprising the investigation undertaken some years ago to determine the value of peat fuel for the production of power. This report presents the results of careful investigation and shows the same careful preparation that has marked two previous reports printed in our Journal.

The former reports, "The Utilization of Peat Fuel for the Production of Power," and "Peat, Lignite and Coal," dealt mainly with the production of power through the media of gas producers and internal-combustion engines, whereas this report sets forth the results obtained with peat when burned on the grate bars of two distinct types of steam generators.

An examination of the results described in detail will show that under favorable conditions peat fuel can be economically utilized for the production of power through the media of the steam generator and steam engine. But the factor which determines the feasibility of using peat fuel for steam generation is the cost of winning this form of fuel and delivering it to the steam power plant in a sufficiently dry state. That this cost of the peat fuel delivered to the plant must be less than that of a quantity of good steam coal equivalent in heating value, in order to permit competition, is apparent to all who have knowledge of the use of low-grade fuels. Moreover, when considering the utilization of peat fuel for the generation of steam on a large scale the important fact that peat fuel, as it is manufactured by the only economic process known today, is much bulkier than coal possessing equivalent heating value, must not be lost sight of. Hence, the storage of a sufficient quantity of peat fuel necessary to permit the continuous operation of a power plant without disastrous interruption becomes a problem of great importance, and one that must be worked out with the greatest care if the desired economy resulting from the use of this low-grade fuel is to be realized.

Further, the handling of large quantities of peat fuel involves problems of a more or less serious nature on account of its bulkiness, and low heating value, which necessitates the burning of an appreciably larger quantity than when burning a steam coal of good quality. On the other hand, the fact that

peat fuel burns freely to a fine, easily handled ash, with almost complete combustion, must not be ignored. The cost of handling the ash can be reduced to a minimum.

The maximum cost per ton that peat fuel can stand, and still compete with coal, is governed by the cost of steam coal at the place where the power plant is situated. There is, however, a fixed minimum cost, determined by the cost of its manufacture, below which peat fuel cannot compete with coal. Speaking generally, it is safe to say that peat fuel for steam-raising cannot compete with good steam coal costing $5 or less a ton. But as the price of coal has been increasing and promises to increase at a more rapid rate in succeeding years, peat fuel for steam generation, wherever large deposits of peat suitable for fuel purposes are available, will become an important competitor of coal. However, economy and efficiency are the slogans of these modern times, and, in the future, it is hardly likely that any form of fuel will be utilized for steam generation for the production of power unless steam is indispensable to the carrying out of some chemical process, or other industry. So far as the generation of power is concerned, the more economical method to employ is the conversion of the peat fuel into a combustible gas which can, in this form, be burned in a gas engine or used for the different heating furnaces in metallurgical works.

Many of the peats so far examined in Canada have a very high nitrogen content, which can be recovered in the form of ammonia, when the peat is burned in a by-product recovery producer. In this manner, many of the peat bogs can become the source of one of the most valuable artificial fertilizers—ammonium sulphate—the demand for which is continually increasing.

As regards the necessity for utilizing the enormous quantities of heat energy lying dormant in the vast peat bogs distributed throughout the Provinces of Ontario and Quebec, much has been written, and need not be reiterated here.

PEAT AS FUEL IN THE SWEDISH STATE RAILWAYS.

Owing to the difficulties experienced in connection with the coal supply, the Swedish State Railway authorities some time ago appointed a special committee to inquire into and report upon the practicability of using powdered peat as the fuel for its locomotives. The report being entirely in favor of the project, there is every prospect of the substitute fuel being adopted on a very large scale in Sweden. As a commencement, all the locomotives running on the Jalkoping-Nassjo line, a

distance of about 60 miles, are to be adapted for peat firing, and works capable of producing 20,000 tons of powdered peat per annum are to be established in proximity to the Hasthagen peat depots near Lake Vetter. According to the experiments carried out by the committee, powdered peat is a practicable substitute for coal, not only as regards its heating capacity, which is about two-thirds that of coal, but also for other reasons, which will become more evident as experience is gained as to the best method of utilizing the new fuel. The new undertaking will be entirely carried out by the State. The cost acquiring the peat-bearing land both soil and subsoil (which is stated to comprise sufficient peat for 20 years' working), the peat-powdering works and plant for an annual output of 20,000 tons, a branch line from the works to the main line, and the fitting of the locomotives with peat-burning apparatus, is estimated at about $350,000. The cost of the new fuel will, it is anticipated, amount to only 15 kroner (about $3.91) per metric ton, delivered on rail at Jalkoping, the corresponding price for coal, taking the lower calorific value of peat into account, being 22¼ kroner (about $5.75.) —(Indian Engineering, vol. 61, 1916, p. 247.)

REPLACING COAL WITH PEAT AT STAVANGER, NORWAY.

The difficulties of getting coal and coke in Norway during the past winter have emphasized the necessity of providing for next winter, and the attention of the municipal authorities at Stavanger has therefore been turned to the extensive peat marshes in the vicinity. Work has just begun on one of the large marshes known as "Store Mose," which for hundreds of years has lain untouched. This marsh has an area of 250 acres and contains practically an unlimited quantity of peat which has proved to be as good as the best Swedish peat. The depth of the peat is about 5 yards. There should be at least enough material in this one marsh to supply the district for many years.

The present custom of treating the peat is not considered the best and the project will be undertaken on a much larger scale. A company has been formed with a minimum capital of $26,800 and a maximum of $53,600 to operate on the "Store Mose." Machinery for cutting up the turf has been ordered from Sweden, where the methods for treating peat are advanced. The work will be undertaken immediately.

Another concern has obtained the right to use a marsh at Naerstrand, in this district, which has an area of 5 acres

and is between 6 and 8 yards deep. Trees have been removed and two machines have been obtained to take out the peat. An expert from Sweden has been hired to take charge. It is hoped during the summer to take out 600 to 1,000 tons of peat, which can be used for the factories.

Other projects of the same kind are under consideration. The city itself has taken up the matter and is measuring certain properties where there is a supply of peat. Engineers have also gone to Sweden to study the methods of treating peat.

Price of Peat and Coal.

The price as established by the government is 21 crowns ($5.63) per ton. Buying peat at this price would be equivalent to buying coal at 125 crowns ($33.50) per ton. Coal, however, is no longer obtainable at this rate. In fact, it is not obtainable by ordinary users at all. The municipality has seized all coal and gives out only limited quantities on cards to such factories, etc., as absolutely need it. This coal is obtained practically at cost, as was the coal that householders had during the winter. (A report on the restrictions placed on the use of coal in Stavanger was published in "Commerce Reports" for Mar. 27, 1917.)

The municipality has just purchased three boats for about $260,000 each to bring coal from England.

Demand for Peat-Cutting Machines.

Although there is at present a demand here for machinery to cut out peat, it is doubtful whether any could be advantageously obtained from the United States. Swedish machines are most efficient and are considered superior to all others, as the Swedish methods are known to be excellent. Even if the United States could furnish machines equally as good or better, the high freights would make their price almost prohibitive, and as soon as the freight goes down, coal itself can be obtained to replace the peat. It can, of course, happen that once the custom of using the peat is introduced it will continue, whether coal is brought in or not, for certainly by using peat the district is economically more self-supporting. In such a case there might be a demand for these machines which Americans could profitably cater to.—Consular Report.

PEAT PRODUCTION IN NORWAY.

The interest shown of late in peat production in Scandinavia was recently discussed by an expert who has been looking over the large deposits of this fuel in the vicinity of Stavanger. According to this engineer there were produced

in Norway 12,000 tons of peat in 1914 and 22,000 tons in 1916, but the production this year would probably go up to 100,000 tons. In Denmark, in 1915, the production was 90,000 tons, in 1916 200,000 tons and in 1917 it is hoped to produce 500,000 tons. Sweden produced 100,000 tons last year.

The engineer says that 216 peat machines are now working in Norway, as compared with 55 in 1916 and 36 in 1914. Among the machines in use now are two automatics; these cost $13,400 apiece and can each be handled by two men, the daily output per machine being 30 to 40 tons of peat. A Stavanger workshop is now turning out 10 peat machines.—(Consular Report.)

PEAT FUEL FOR SWITZERLAND.

The exigencies of war, the lack of developed coal deposits, and the inability to import coal in quantity sufficient to meet the needs of the population have induced the Swiss Government, through a semi-official organization, known as the "Societe Cooperative Suisse de la Tourbe," whose address is Berne, Bundesgasse No. 34, with offices at Laupenstrasse 3, Berne, Switzerland, to resort to the use of turf or peat as a substitute or to supplement the insufficient supply of coal.

The association is in the market for the purchase of improved machinery for cutting, raising, drying, and compressing turf. On account of its low calorific properties, turf or peat as a fuel is not a satisfactory and complete substitute for coal, particularly for steam generation, but in those parts of the United States where it abounds it may be used to advantage for domestic consumption by admixture with coal, saving the expense involved in transporting coal from a distance and producing sufficient heat.

How the Turf Will Be Prepared.

In its appeal to the people, the association says: "The Swiss turf association plans the exploitation of turf by machinery in vast quantities. By employing machinery the usual defects which have hindered the use of turf as a fuel will be overcome. These defects have been the tendency to absorb moisture, thus reducing its heat properties; its easy crumbling, causing wastage of material; its bulk, which involves increased freight charges and the necessity for the enlargement of fireplaces for its use. The employment of machinery will enable the pressure of turf into compact form while extracting the water. This will be obtained by tearing the roots and plant fibers and unequal construction and reducing it to uniform size, and by drying it in the air. The result will be a reduction in

bulk to one-fifth of the raw material with a specific gravity of 1.2. Furthermore, it will be hard and resistant, and through the formation of a hard and gelatinlike skin, which forms with the drying, the reabsorption of moisture is prevented, making machine-handled turf incomparably better than that which is treated by hand."

The Swiss Government reserves the right to requisition the entire stock of turf on hand as well as all turf fields, and the Economic Department will fix maximum prices as soon as the exploitation has assumed considerable proportions.

Shortage of Coal-Supplies of Turf Available.

The question of the present and future supply of fuel is an alarming one to the people of Switzerland. The quantity of coal now imported is insufficient, even when consumed under rigid economy, and the proposed substitution of turf is designed to relieve the stress of the situation.

The monthly needs of the country amount to 280,000 metric tons of coal. The promised supply of 253,000 metric tons from Germany is not forthcoming, as shown by the following figures: Imports in September, 1916, 234,500 metric tons; October, 216,700; November, 210,000; December, 187,400; January, 1917, 197,000; and February, 116,000.

The results are particularly felt not only in the high price of coal, but in the reduced number of trains in operation and in restriction upon the consumption of gas.

The people of Switzerland have at all times consumed a large quantity of wood for domestic heating, particularly in the country and in the small villages, large tracts of timber being owned and scientifically conserved not only by the cantons but by the consumers. But in the larger towns gas is extensively used for cooking, and for the production of gas wood is unsuitable. Turf can be used in the production of gas with a by-product of ammonia of about 0.4 per cent, which is valuable for agriculture.

A survey has been made of Switzerland's turf fields and it is found that they cover 12,355 acres, from which 85,003,500 cubic yards of green turf can be extracted, representing 1,507,990 cubic yards of dried turf, ready for use.

Some 30 years ago these deposits were extensively exploited, but they were gradually abandoned on account of the cheapness of imported German coal.

Prices of German Coal.

The present prices for turf vary from $2 to $4 per cubic yard, but it is expected that the maximum prices to be fixed

by the government will be lower. The prevailing prices for German coal are as follows:

GRADE	Prices per 10,000 kilos or 22,046 lbs. Taken at Coal mine in Germany	Taken at Mannheim or Rheinau	F.O.B. Basel Switzerland	F.O.B. Schaffhausen, Switzerland
Industrial coal:				
Saar coal	$131.24	.....	$148.61	$152.47
Ruhr coal	122.25	137.99	151.50	154.40
Domestic coal:				
Ruhr, small coal, cobbles, nuts	131.24	146.68	160.19	163.08
Ruhr anthracite	135.10	150.54	164.05	166.94
Rhine brown coal briquettes	80.09	93.60	107.11	100.00
Coke:				
Large size	128.24	143.78	157.29	160.19
Crushed	.....	.....	180.43	183.35

These prices, it is believed in industrial circles, will probably be increased 20 per cent by August 1st, 1917.

The Swiss Turf Association will endeavor to deliver turf as cheaply as possible, in order to reduce German coal prices, or at least to prevent further increase. It is believed that German coal would already have commanded higher prices but for the fear that the Swiss people would begin to substitute turf.—Consular Report.

The Management of Muck Land

By H. R. SMALLEY, ANGOLA, IND.

(Read at Washington Meeting, Sept. 22, 1917)

In the development of new muck land and in establishing profitable types of farming it, a number of factors must receive careful consideration. Among these are distances to market, land clearing, drainage, soil management, and the selection of proper crops. Owing to the fact that muck soils are capable of supporting such a variety of types of farming, it is usually possible to adjust a system of farming to whatever conditions are encountered. Such staple crops as corn, hay, oats, and wheat are being grown more and more on muck land and the acreage of these crops can be greatly extended without materially affecting prices. It is evident, therefore, that extensive types of farming should predominate on the greater part of this land, at least for the present and immediate future.

Distance to Market.

All practical growers realize the importance of locating near a market or shipping point, but many beginners in the business make the mistake of locating so far from a market that the cost of hauling the products greatly reduces the profits or consume them entirely.

At four miles from market or shipping point muck land loses much of its value for trucking. At a distance of five or six miles from market it is worth as much for extensive as for intensive farming. This relation may be changed in the future and is being changed in some localities by the introduction of cheaper methods of transporting bulky products from the farm to market or shipping point, but it will always have much influence on the type of farming and the utilization of new muck land, and should be a matter of important consideration for those who contemplate locating on this type of soil.

Clearing Muck Land.

The cost of clearing muck land depends altogether on the character of the native vegetation. A great deal of this land requires practically no clearing, being covered with a good sod of wild grasses and a few shrubs. This is true of very large areas of marsh land in Indiana, Michigan, and neighboring

States. Muck land that has supported a growth of tamarack, black ash, or elm can usually be cleared at a cost of $15 to $30 per acre. As a rule swamp-land stumps are shallow rooted and the soil is loose so that they can be pulled with a team and a simple stump-pulling device.

Drainage.

The fairly rapid settling of new muck land necessitates the laying of tile drains deeper than on other soil types. If the fall permits, drains should be placed at a depth of 3½ to 4 feet. If they are placed nearer the surface, uneven settling of the soil will frequently throw the tile out of line, thus ruining the drain, and even if this does not occur it will become rapidly less efficient as the surface settles toward the level of the tile. Numerous muck fields have been seen by the writer where tile drains which had been laid at a depth of 2½ feet 8 or 10 years before were being uncovered with an ordinary breaking plow.

It is sometimes advisable to dig open ditches, as a temporary measure, to be replaced later by a permanent system of tile drains. Where higher land borders on muck, it is very important to lay a drain around the border to catch the seepage from the high lands. If this is not done there will be wet spots just inside the border of the muck.

A definite plan should be worked out and followed in all drainage work. Usually time and money will be saved by procuring the services of a competent drainage engineer, as you gentlemen well know.

Soil Management.

The muck soil of northern Indiana and southern Michigan shows a wide range of variations. In some places it is as deep as 10 to 20 feet, the lower layers being composed of peat in various stages of decomposition; in other places the muck grades off toward the higher surrounding land and is intermixed with a large proportion of sand or clay, resembling black loam, and by some writers is characterized by the term "march border" soils.

The native vegetation on these soils varies as much as the soils themselves. In some marshes black ash and elm predominate, some support a growth of tamarack, and still others were originally open prairies covered by a heavy growth of marsh grasses and a great variety of mosses, weeds, and shrubs. Occasionally huckleberry and cranberry marshes are found. Still less frequently small areas are covered with dewberry briars. These latter types of vegetation usually grow on soils that are very deficient in lime.

When first broken up this soil is usually loose and spongy, gradually decomposing upon exposure to the air by drainage and tillage. This results in continued settling, the amount of which will depend upon the original depth of the muck. The farms studied by the writer had been farmed for an average of 12 years, and during that time had settled at the rate of about an inch a year.

Muck soils are radically different from other types, owing to the fact that they have been formed almost wholly from the decay of vegetation, whereas the heavier types have been formed by the processes of rock weathering. Clay, loam, and sandy soils are frequently in need of organic matter and nitrogen, whereas muck soils are usually lacking in certain mineral constituents, especially potash and phosphates, and occasionally lime. On most muck soils in this region potash is the most important fertilizer ingredient needed, though the application of available phosphates usually produces beneficial results.

Farm experience, field experiments, and soil analyses have all clearly demonstrated that, excluding drainage, the fertilizing of muck soil is the most important factor in determining farm profits on muck land.

Many muck soils have produced fairly good crops for a year or two, after which production has diminished rapidly unless fertilizers or manure were applied. Some muck soils are so deficient in potash that they will not produce anything even when first broken up, so that the most experienced farmers use fertilizers or manure from the start without waiting to determine whether a crop can be produced without reinforcing the meager supply of mineral plant food already in the soil, thereby running the risk of losing a crop.

Nitrogen is present in all muck soils in abundance, but it is probably fortunate that only a small part of it is available for any one year. On new muck land and for intensive crops it may occasionally be profitable to use fertilizers containing some nitrogen, as the bacteria that render soil nitrogen available are not always present in sufficient numbers in new muck. It often happens that on new muck lands manure is especially valuable, as it inoculates the soil with bacteria, at the same time adding considerable mineral plant food in fairly available forms. But after muck land has been farmed for a few years it is doubtful whether the application of nitrogen-carrying fertilizers is necessary.

Potash alone is usually applied to muck land in the form of commercial muriate of potash. The more expensive sulphate of potash is thought by some to produce better quality

in onions, potatoes, and other truck crops, but these claims do not seem to justify the extra expenditure for the higher-priced form of potash. On muck soil that has not been previously fertilized or manured, it is customary to apply 100 to 200 pounds of muriate of potash per acre for extensive crops, or corn and small grain crops, and 200 to 400 pounds per acre for truck or intensive crops. This application is repeated every two or three years, or a smaller amount is applied every year. This treatment usually gives excellent results, the yields frequently being increased 50 to 200 per cent over the yields of similar untreated land. A large amount of ready-mixed commercial fertilizer is also used on the muck soil in this region. The potash content of these fertilizers ranges from 8 to 15 per cent, and the available phosphate from 5 to 10 per cent. From 150 to 300 pounds per acre are used on extensive, and from 300 to 1000 pounds or more per acre on intensive crops. The phosphate induces earlier ripening of crops, better quality and a somewhat higher yield.

At the present time (1916) the supply of commercial potash in this country is so low that little is available for fertilizer and the price is prohibitive. Every effort should be made to conserve the potash already in the soil. Farm manures and crop residues have a relatively higher value at the present than when the fertilizer supply is normal and will give excellent results when applied to muck land. Farm manure contains on the average about 0.5 per cent, and fresh straw 0.5 to 1 per cent of potash, which is readily soluble in water and available for plant growth. It is, therefore, very important to prevent the undue leaching of manure in order that it may give the best possible results when applied to muck land. Many growers prefer manure to commercial fertilizer for truck crops. For general crops, 6 to 8 tons of manure per acre will probably be more profitable on muck land than on any other soil type.

Preparation of the Seed Bed.

In order to obtain a good seed bed, deep muck should be compacted by means of a roller, the heavier the better. Many muck farmers roll several times with an ordinary roller, sometimes weighted with stones, and on a few of the larger farms extra heavy rollers weighing 3000 to 5000 pounds, and pulled either by a tractor or by horses, have given excellent results. As regards spring-planted crops, danger from frost is much reduced when the soil has been thus compacted.

Cropping Systems.

In the case of muck soils there is little need for growing crops that replenish the supply of nitrogen and organic matter in the soil; hence the growing of legumes is not essential. Rotation of crops, or rather a change of crops on muck soil is desirable, however, as a means of controlling insect pests and plant diseases, and of securing a proper seasonal distribution of farm labor. Farmers who are specializing on crops like onions, celery, or peppermint do not care to give much attention to their minor crops, and hence usually change crops only when their principal crops are threatened with some insect or plant disease.

Of the general crops grown on muck soil, corn is the most important, though hay and grain are usually profitable. A rotation consisting of corn two years, oats and wheat one year each, and hay two years is well adapted to this soil and provides a good distribution of labor, especially if a sufficient amount of livestock is kept to furnish some work during the winter months. Some corn, hay, oats, and all of the wheat can be sold, which, together with receipts from livestock, will provide enough diversity to insure a fair degree of stability in the farm income. More and more muck land will eventually be utilized by farmers for the production of general crops.

Norwegian Company to Manufacture Peat Fuel. A company is in process of formation in Norway for making fuel from peat by the Rosendahl method. The capital of the company is to be between 600,000 and 1,000,000 crowns ($160,800 to $268,000). The raw material for the new industry will be chiefly peat from the extensive Norwegian moors, but any organic material may be used that is sufficiently abundant in the neighborhood of the factory, for example, wood waste. The product is said greatly to resemble English coal. Preliminary experiments have been conducted not only in the laboratory but also under factory conditions on a small scale, and the product is stated to have been satisfactorily tested in Christiania households.

Study of Nitrogen in Peat.—C. A. Morrow and R. A. Gortner (Soil Science, vol. 3, 1917, p. 297.) The results of a study of the nitrogen distribution by the Van Slyke method in different soil types is given. Seven samples of mineral soils, an acid peat, a calcareous peat, an acid sphagnum-covered peat, and extracts of a sphagnum-covered peat solution

in (a) 1 per cent HCL, (b) 4 per cent NaOH but precipitated by acid, and (c) 4 per cent NaOH and not precipitated by acid were examined. The figures for the ammonia nitrogen in a protein analysis are not appreciably changed when the hydrolysis is carried out in the presence of an ignited mineral soil equal to 20 times the weight of the protein material. The "humin" nitrogen was greatly increased by hydrolysis in the presence of ignited mineral soil. The histidine fraction entirely disappeared. A new fraction of organic nitrogen was isolated from a colorless solution by Ca, Fe, and Al hydroxides on the addition of $Ca(OH)_2$. It consists principally of a material of non-protein origin. Results gained from a study of different soils indicate that the organic nitrogen dissolves during hydrolysis, to almost the same extent, regardless of the origin and nature of the soil. The organic nitrogen distribution in different soil types is very uniform.

IRISH PEAT DEPOSITS.

The British Press Bureau has issued the following for publication:

The Fuel Research Board, with the sanction of the committee of the Privy Council for Scientific and Industrial Research, has appointed a committee of inquiry into the utilization of Irish peat deposits. The terms of reference to the committee are as follows: "To inquire into and to consider the experience already gained in Ireland in respect of the winning, preparation, and use of peat for fuel and for other purposes, and to suggest what means shall be taken to ascertain the conditions under which, in the most favorably situated localities, it can be profitably won, prepared, and used, having regard to the economic conditions of Ireland, and to report to the Fuel Research Board."

Though the inquiries of the committee will ultimately lead up to the consideration of peat as a source of energy in central power-stations, there are sound reasons why this aspect of the problem should be postponed to a later stage. On the one hand, the Fuel Research Board is already organizing an extensive inquiry into the problems of fuel economy in connection with power production, and the results of this inquiry will supply the fundamental data and information required when the time comes for the consideration of any wide scheme of development in Ireland. On the other hand, any schemes of development must be based on more exact knowledge than is at present available regarding the selection of the more favorably situated bogs and the possibilities of win-

ning and transporting partly dried peat to centers at which it may be converted into marketable products. It is obvious, therefore, that the inquiries of the committee are likely to be most fruitful if they are concentrated on the fundamental problems, for until these are settled no satisfactory progress can be made.

All communications should be addressed to: The Secretary The Peat Inquiry Committee, University College, Dublin.

Manufacture of Bacterized Peat.—(W. Thompson, Br. Pat. 103,142; 1916.)

Peat is saturated with the effluent from a septic tank (or from farmyard manure) which has, preferably, been exposed to air, at 20° to 30° C, and treated with a very little milk. In this way the peat is broken down by aerobic organisms the action of which is furthered by spreading the mixture in thin layers on trays. If a liquid manure be required, the freshly treated peat is mixed with twice its bulk of soft water and allowed to stand, more water being added subsequently if desired. After the aerobic treatment, dry, finely powdered slaked lime (or soil, or sand) is added to render the material neutral, to accelerate the drying, and to prevent "coagulation," that is, setting to a tough mass on drying. Setting can also be prevented by stirring or blowing in air from below. A more active manure can be obtained by inoculating the prepared material with special aerobic cultures. The finished product should be allowed to stand for 18 to 20 days before it is put on the land.

Apparatus for Treating Peat. (W. L. St. J. Prioleau, Br. Pat. 105,296, 1916.) According to this invention, the raw peat is subjected to a mechanical macerating treatment by means of crushing rolls, those after the first pair advantageously being supplied with a heating medium, the crushed material being carried from one pair of rolls for delivery to the next, located at some little distance away, by means of a vibrating tray, or trays, or chute; the trays will be made with perforated bottoms, through which the free water may pass, thus relieving the peat mass of some of its water contents before it reaches the next pair of rollers; the trays or chutes will be inclined at such an angle as to cause the progressive forward movement of the peat. The rolls may be serrated either longitudinally or transversely; for instance, the first pair may be serrated longitudinally, the second pair with coarse circumferential grooves, and the third pair with fine circumferential grooves, or the third pair may even have a smooth surface

in certain cases. The general arrangement of the apparatus consists of a source of peat supply with the peat in its raw condition. The first pair of rolls are supported on a framework and a similar framework supports the other end of the several rolls and the other mechanism; the rolls are serrated longitudinally, and will usually not contain heat, as the peat at this stage is very wet. There are a second pair of rolls, having their surfaces serrated with alternative grooves and ridges of coarse character; and also a third pair of rolls having their surfaces serrated, with fine grooves and ridges. These rolls are advantageously supplied with heat from a steam generator by pipes and glands passing steam through a hole in their supporting shafts. A drying drum or roller also supplied with steam extends across the length of the machine, and carrying, with the aid of a forward roller and an intermediate roller a heavy felt blanket or band extending across the full width of the rolls. This blanket rotates about the rollers so that as the peat falls from the rolls it is carried forward over the end of the roller and removed by the scraper, so that it falls upon the second pair of rolls. The same action happens with regard to the drying band carried by the steam-heated drying drum, the forward roller and an intermediate roll, the material being carried forward in this case so as to drop on the rolls upon removal by the scraper. Beneath the rolls a press of ordinary character, but preferably provided with a filtering mechanism, is provided and driven by any suitable power unit represented by a wheel; the passage of the material along the travelling blankets removes the greater part of the moisture from the peat, consequently it is approximately dry on passing from the rolls to the press and it can be briquetted by pressure, assisted by the remaining moisture, into briquets, which, falling on the conveyor, will be of such strength that they can be conveyed away to where they are required, for instance, to the inlet of the retort where they are being treated, say, for the extraction of their volatile contents.

The filter press on the briquet press will remove any surplus moisture not required for the briquetting process. In case the briquets are required only for fuel, binding materials may also be added to the peat while passing through the press. The freezing process, if such is used, would be applied before reaching the delivery hopper, and owing to the great temperature difference between the cold and the heating rolls, a more efficient breaking up of the cellular structure is attained when it is desired to remove the moisture more quickly and thoroughly.

Carbonizing of Peat. (C. Whitefield, Br. Pat. 106,121, 1916.) The apparatus employed in this process is similar to a power gas producer. Within the upper part of the carbonizing chamber is fitted a series of revolving plates and fixed scrapers, the former being carried by a central shaft, and the latter (one of which lies immediately above each plate) being adjustably and removably carried by the sides of the producer. The revolving plates are carried by a central shaft, the upper end of which extends through the upper end of the producer and is there fitted with a bevel wheel. Meshing with the wheel is a further wheel carried by a horizontal driving shaft. In the lower part of the producer is an arrangement of gas burners, supplied with gas and air under pressure. The position of the burners, relatively to the bottom revolving plate, is such that only the gaseous products of combustion can reach the material to be carbonized, the lower part of the chamber being closed against the ingress of free oxygen, in order that the products of combustion shall be of a neutral or reducing character.

When the peat is fed into the producer, it falls upon an upper revolving plate, from which it is swept by a fixed scraper through an aperture in the plate. Falling on to a second plate below, the material is swept off by another of the scrapers on to the next plate below, and so on with each succeeding plate, until the material, fully carbonized, finally drops on to the lowest fixed plate, or into the lower part of the producer, whence it may be withdrawn. As the material moves down, the distillates are carried upwards by the products of combustion, and away to the outlet.

Owing to the products of combustion gradually losing their sensible heat, and being of either a neutral or reducing character, no combustion of the material itself takes place, and as the temperature is gradually falling, those distillates which evaporate at a low temperature are not detrimentally affected. As the material passes from plate to plate, it is spread out over a large area, and is gradually heated by the products of combustion. Similarly, the products of combustion and the distillates meet the cooler materials as they pass to the outlet. In this way the highest yield of distillates is obtained at a comparatively low temperature. The distillates, after leaving the producer, are condensed by any suitable cooling appliance; and in this connection, it is pointed out that the steam or watery vapors condensed out of the distillates may, after cooling, be used to cool the new distillates. Further, the heat produced by burning the non-condensible

products may be used for the re-evaporation or concentration of the distillates.

Peat Cutting Machine. (R. Fleck, Br. Pat. 106,162, 1916.) A machine for cutting peat comprises a frame supported at its front and rear ends by rollers, one roller carrying a number of rotary cutters which cut the peat into strips. Stationary knives having vertical and horizontal cutting blades are secured to a cross-bar of the frame by bolts. A shoe holds down the peat during the operation of the horizontal cutters. For transport the rear end of the frame is supported on wheels mounted on axles carried by links pivoted on a shaft. These links are swung round to a vertical position so that the wheels hold the cutters above the ground. Pins secure the links in their vertical positions. The machine travels over the ground in two directions at right-angles to each other. The distance between the knives may be varied.

Preparing Peat for Distillation.

(W. L. St. J. Prioleau, Br. Pat. 106636, April 14, 1916.) Apparatus for obtaining volatile products from carbonaceous materials containing a considerable quantity of moisture, comprises an upper enclosed compartment acting as a preliminary drying and heating appliance, and a lower closed retort in which distillation is completed. The material traverses the upper section by means of a conveyor belt and scrapers and is then fed into the lower section along which it is transported by a screw conveyor. The vapors evolved are withdrawn at successive points in both sections and separately condensed.

LATE NOTICE

It is with considerable regret that we have to advise that our Secretary, Mr. Julius Bordollo, suffered a severe stroke on September 13th last. Owing to his present health we request members and readers to address all correspondence for our Secretary to the Society, 17 Battery Place, New York City, until further notice.

Last reports stated that our Secretary is slowly improving and resting easy.

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If you are interested in any degree whatever in Agriculture, Power and Fuel, Chemistry or any other uses of Peat, you should let us help you and you help us by becoming a member of the American Peat Society.

OBJECTS AND FOUNDATION.

Founded at the Jamestown Exposition on October 23rd, 1907. Its object is to further the interest in the uses and application of peat for industrial and economic purposes.

PUBLICATIONS.

The Society holds one general meeting per year, and publishes a Journal quarterly, which is sent to all members in good standing. The journal includes the proceedings of the meetings, original papers on practical experience, etc., also abstracts on all contemporary literature and patents, thus all the latest agricultural uses, fertilizer purposes, drainage, fuel, uses, technical uses, etc.

SOME ECONOMICAL POINTS OF INTEREST.

Prof. Chas. A. Davis, U. S. Bureau of Mines, estimated that there are about 12,000 sq. miles of workable peat beds in the United States, outside of the large number of beds very advantageously adapted for agricultural purposes, etc. He gave as a conservative estimate a yield of 200 tons dried peat per acre foot.

Canada has at least 37,000 sq. miles of known peat deposits.

About ten million tons of peat are used in Europe each year.

GENERAL INFORMATION AND INQUIRIES.

All members have the privilege of making inquiries regarding general information about peat and its uses, by addressing the Secretary of the Society.

It must be understood that only general information and of a general character can be given. Members can obtain the names of experts in any special line, from the Secretary of the Society.

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